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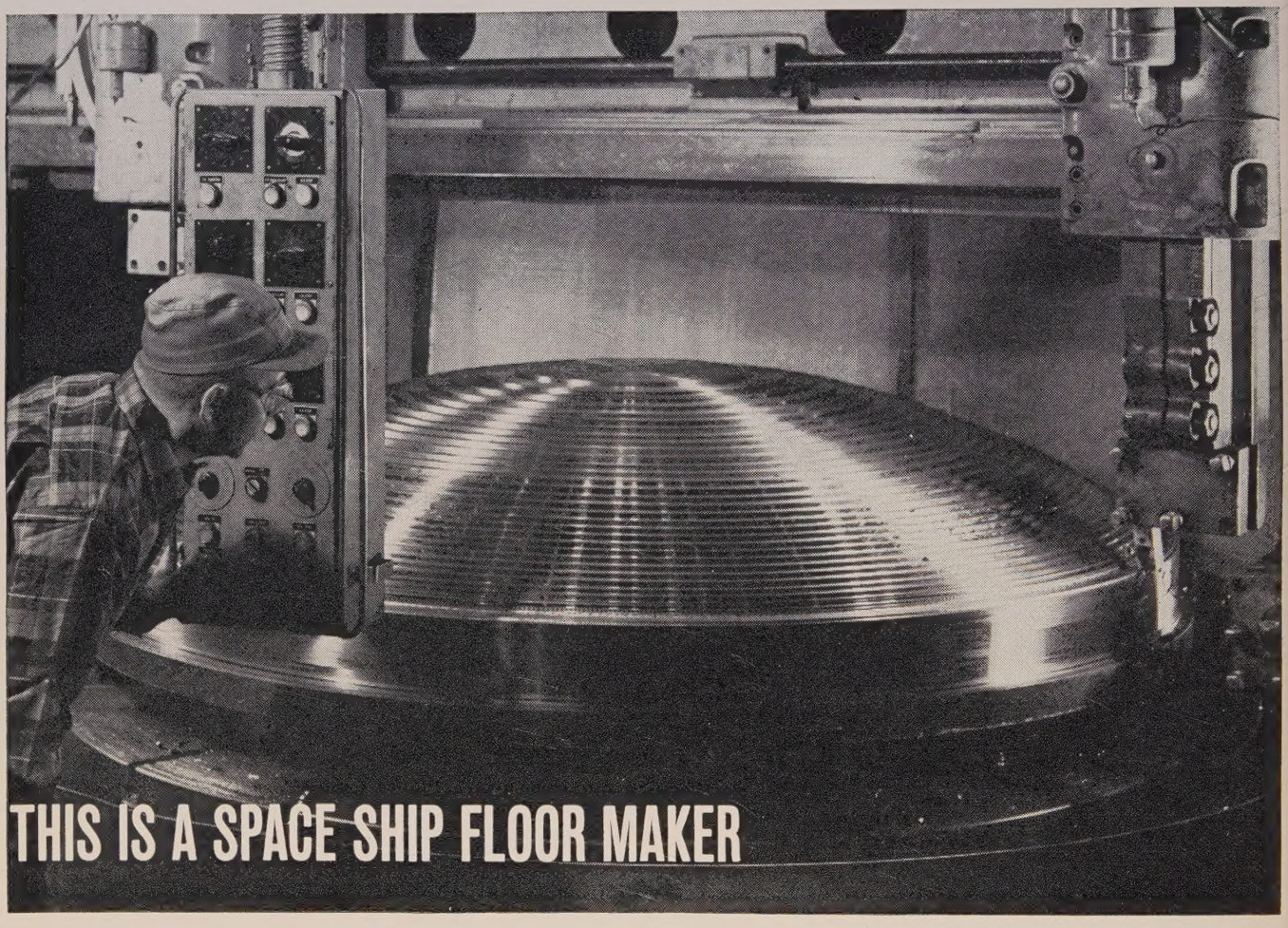
Sometime within the next several years, the first American will soar into orbit around the earth. He will be sealed in a small, cone-shaped space capsule mounted atop an Atlas missile. The missile will climb 100 miles in less than six minutes, where the capsule will disengage and go into orbit. The man will be alone in space.



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THE ILLINOIS TECHNOGRAPH

Volume 76, Number 8 **May, 1961**

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Cover . . .

The circular patterns on our cover this month are Barb Polan's interpretations of clutches as discussed on page 6 through 8.

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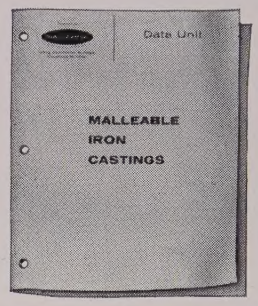

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FACTS ABOUT
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FOR ENGINEERS

Who is eligible?

College graduates, with a degree from an accredited college or university, who are U.S. citizens 20½ to 27½ at time of application. Male applicants may be married or unmarried; female applicants must be single and have no dependents. Applicants must complete written and physical examinations for commissioning.

What kinds of engineers are needed most?

Aeronautical, electrical, mechanical, civil, architectural, industrial. (Also graduates with any degree who majored in nuclear physics, engineering physics or meteorology.)

What is Air Force Officer Training School?

A precommission training course of 3 months' duration at Lackland Air Force Base, Texas. Officer trainees upon graduation receive a commission as second lieutenant. They are then assigned directly to duty or additional training.

Does the Air Force offer career opportunities?

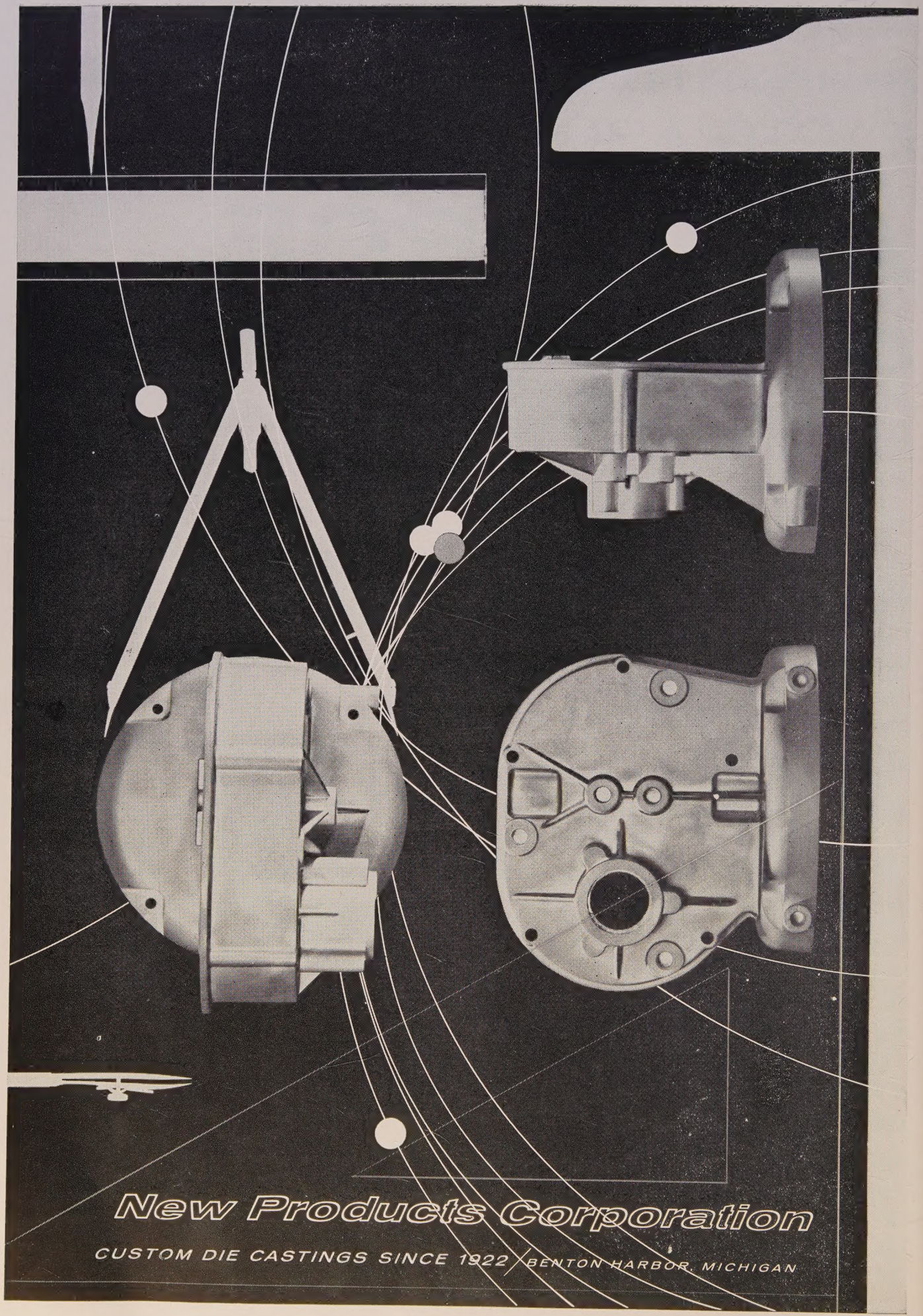
Yes. Technically trained officers have a particularly bright career outlook. They have good opportunities for graduate study.

How can further information be obtained?

Write to OTS Information, Box 7608, Washington 4, D.C., or inquire at any Air Force Recruiting Office, listed in the telephone directory under "U.S. Government—Air Force."

Civilian Career Opportunities

The Air Force also offers challenging jobs for engineers as civilians. Write to Directorate of Civilian Personnel, Hq. Air Force Systems Command, Andrews Air Force Base, Washington 25, D. C., concerning opportunities for individuals with degrees in aeronautical, electrical, electronic, and mechanical engineering. Write to Directorate of Civilian Personnel, Hq. Air Force Logistics Command, Wright-Patterson Air Force Base, Ohio, concerning opportunities for individuals with degrees in industrial engineering.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Who is to say?

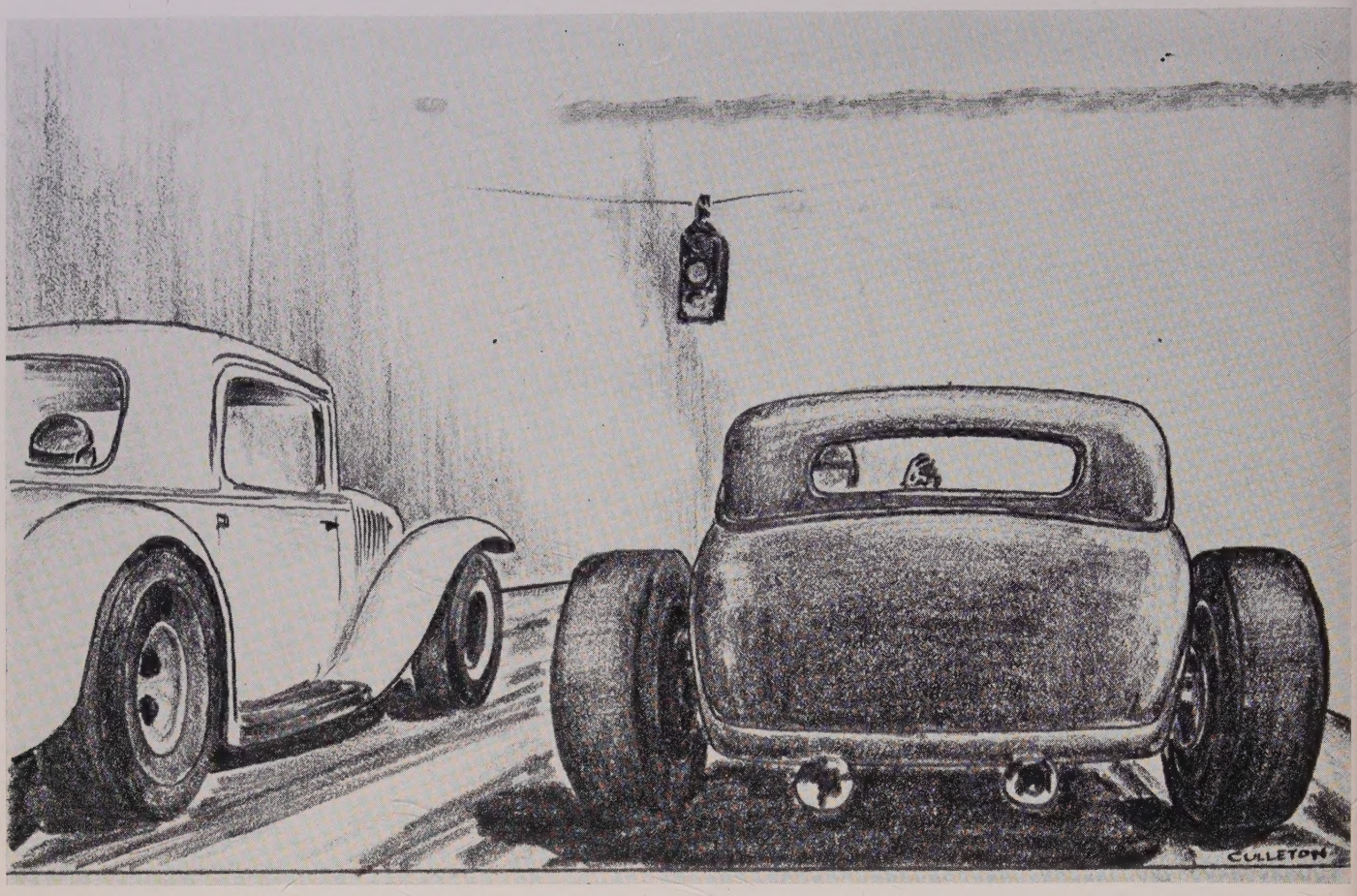
The University of Illinois is a large school, and although in a minority, there exist almost sixty fraternities. Students join a fraternity and thereby choose many of their college friends. Each fraternity chooses its own scholastic atmosphere, social life and athletic program. Each group also selects its members. Whether written or spoken tradition, there exist criteria for member selection. Certainly men may choose their roommates in such private housing.

Although a fraternity is a separate group living under its own rules as well as those of the surrounding society, many fraternities are members of a national fraternity. The "national" may have certain restrictions to membership. The rule-making segment of the national is comprised of representatives from each chapter. Therefore, the individual chapters control the fraternity's laws. If any chapter disagrees it has the option to withdraw from the "national." We may then assume that whether the membership restrictions are local rules or "national" decrees, the individual chapter agrees. If this group of students wants to choose future members by certain criteria, who can say they are wrong? Who cares if a private organization discriminates (Webster's, v.t. selects). People who try to force universities to unjustly limit fraternities and universities weak enough to submit to such action should reevaluate the situation. The university may interfere with a fraternity to improve the health and welfare of the group; but when the school tells the group who they must consider for membership, this is going too far. The next step after removal of discriminatory clauses is forcing fraternities into taking all those going through rush. Some group would be forced to take a rushee who would not even be considered by anyone else. The Supreme Court upholds public integration, but private segregation is entirely another matter.

A store or company is equally private; they hire and fire at their own discretion. If we let advancement associations push and force their way, friction will be the only result. As in the case of the misguided union that required all of its talented members to strike so that the employer would be forced to hire second-rate members, a powerful group can cancel competition and wipe out progress.

The Negro is able to raise his own prestige through true competition. A Negro is a human being and should not be discriminated for or against in public situations. Discriminating private groups will open their doors to the Negro when they are good and ready. Simply changing the printed word will mean nothing. Acceptance based on merit will be the only real solution.

—C. H. J.



DON'T PANIC – CLUTCH!

By Charlton Jones, M.E. '62

Hot rodders and engineers should have some background on clutches. This article was written to enlighten the latter group—especially those who gather at the old 224 spot ten to twelve.—Editor.

• • • •

Clutches have had to come a long way in the past sixty years. Torque transmission requirements have leaped from a few pound-feet of torque to 409 pound-feet of torque at 3,600 rpm in the 1961 Chevrolet. The huge engines in the prestige vehicles crank out around 500 pound-feet. Increased engine torque and the racing interest that these engines generate have placed huge demands on today's clutch facings. To better understand the problem automobile designers face, let's look back through the past years of automotive development.

A clutch is simply a device used to control the flow of mechanical power and may be found in different forms. A positive contact clutch might consist of two notched members that slide together and transmit rotation. Although when engaged it would offer no slippage, the shock of engagement would make this type impractical for the main clutch assembly of an automobile. It is used, however, for the high gear drive within the conventional transmission.

Overrunning clutches and unidirectional clutches have many applications but are not the answer to the automotive problem.

Frictional-contact rim clutches serve as brakes to stop the car and in centrifugal clutches drive go-karts, but these cannot solve the problem for our tail-finned monsters.

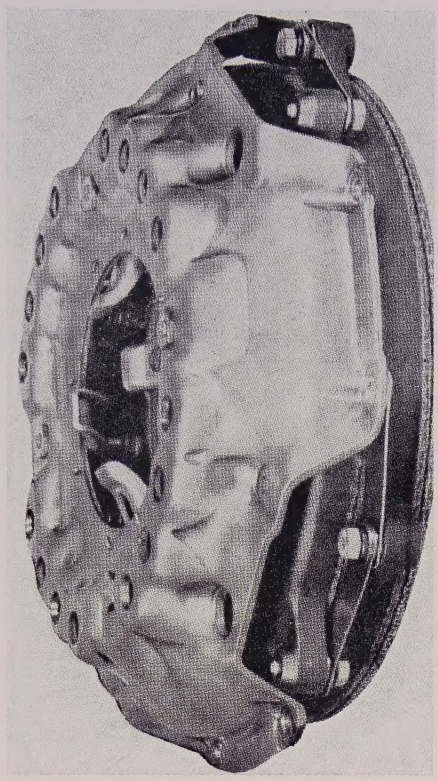
The first successful automotive clutches were of the frictional-contact axial variety. About 1905 the clutches were of the cone type, faced with wood, leather, or cork. These materials allowed only 10-15 psi pressure plates, and although they possessed high coefficients of friction, they lacked strength and heat resistance. Many clutches were tried. Metal-to-metal friction surfaces allowed high unit pressures but required an oil bath to prevent surface scoring. The oil reduced the coefficient of friction to a value well below that obtainable with dry surfaces. About 1910 the multiple disk dry-plate unit was developed to meet the torque requirements of the new motors.

The development of asbestos-base friction facing made possible the single-plate dry-disc clutch in 1915. The torque output of the twenties had risen to about 200 pound-feet. To meet the ever increasing demands of the new power plants face surfaces were improved. Most of today's clutches still employ this design with just better friction materials to match today's torque output.

By 1925 two classes of friction materials were in use by the industry. Woven facings of yarn woven in sheets and die cut or woven in a circular pattern are made from an asbestos base compounded for high frictional and heat-resisting characteristics. Non-yarn materials resembling fiber boards comprise the second class of surfaces, molded facings. Molded materials are actually cut from a rolled asbestos sheet which

are formed on a special paper machine, dried, die cut into oversize rings, impregnated and cured. One type of molded facing is actually made in a mold. Desirable clutch facings should have a high and uniform coefficient of friction. The properties should not be affected by environmental changes like humidity. Damp spells can cause chatter or even prevent clutch release if the friction surface is water sensitive. The ability to withstand high temperatures and to conduct heat away are necessary properties too. Resiliency, flexibility, and wear resistance prevent replacements due to excessive wear. Flexibility allows the largest possible contact area during engagement.

The foundation of most friction materials is organic. Metallic particles or other suitable materials are bonded with organic resins. Several companies are producing sintered bronze facings to attain better properties. Manhattan and S. K. Wellman produce many sintered metal facings. S. K. Wellman and Bendix are both manufacturing a new metallic-ceramic material. Clutch designers are continually striving for better friction surfaces. Tests have been developed for comparison. The burst test is performed after heating the material to 500 degrees F. Failure by centrifugal explosion may occur between 6500 to 12,000 rpm for most automotive applications. Peak horsepower of high-performance factory engines are rated at about 6200 rpm. These engines in the hands of over-enthusiastic hot rodders may reach seven to eight thousand rpm.



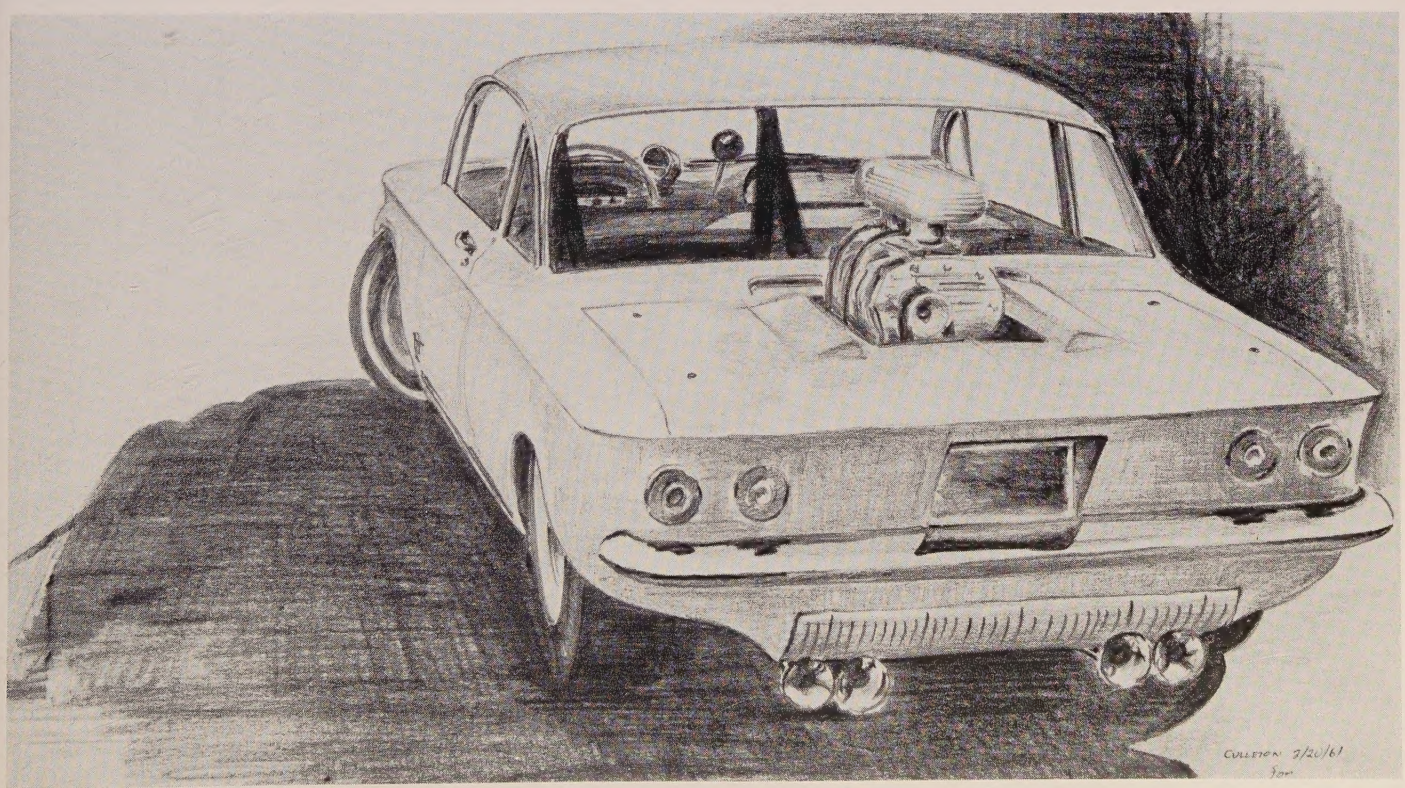
A double disc truck clutch

If valve float and/or engine disintegration do not limit the rpm the next weak point will be noticeable as the clutch explodes.

The slip test performed at 1,125 rpm for 90 seconds is a severe test since a first gear, full throttle start of a car involves only two seconds. A second gear start only involves about four seconds of slippage. During the slip test after about 60 seconds smoke usually appears, and a considerable loss of friction is noticeable in the last 30 seconds. Clutches that pass the slip test are given the wear test. 10,000 repeated engagements over a 27 hour period should produce wear in the neighborhood of 0.002 inches per thousand engagements. Torque observations are also made during the wear test to study any marked change in friction that may occur.

After the laboratory tests pass a material, road tests are performed in all kinds of driving. Hot, damp weather helps to point out the shortcomings of the surface.

Clutch design has been completely taken care of for the production car. The trouble arises when someone increases the torque transmitted and raises the maximum rpm. A clutch with a better surface material and greater contact area may be required. Dragsters and other racing cars that must slip a clutch under great loads employ multiple-disc clutches. There is an airplane-engine-powered dragster that uses an oil immersed tug boat clutch. In every successful racing project the clutch capacity was considered. Even some clutch assemblies designed for racing have been known to fail. If this happens to you, don't panic. Clutch with the next better assembly and hope.



Author's project will require good clutching

The Dean Speaks . . .

PROFILE OF THE ENGINEERING FRESHMAN

By Assistant Dean H. L. Wakeland

After registration each fall one of the first questions to arise in college academic groups is "How does the new freshmen class look?" Similarly, new freshmen, as well as upperclassmen, in engineering are interested in the calibre of the new class as it represents their "competition."

Over the past few years, the new freshmen entering the College of Engineering have continued to improve in calibre if high school percentiles, placement tests, and subject matter presented for entrance is a fair measure of calibre.

In the early 1950's a study was made of the entrance requirements and curricula offered in the College of Engineering. Since that time, continuous reappraisals have changed both entrance requirements and graduation requirements.

Mathematics Preparation

In 1954 the mathematics requirement for entrance was changed from 3 units (algebra 1½ units, solid geometry ½ unit, plane geometry 1 unit) to 4 units (algebra 2 units, plane geometry 1 unit, solid geometry ½ unit, trigonometry ½ unit). In 1956 the mathematics requirement was eased back to 3½ units as the ½ unit of solid geometry was no longer considered mandatory. During this period of changes, the high schools in Illinois improved rapidly in their quality and depth of mathmatics instruction and the students coming to the College of Engineering were better prepared each succeeding year.

Figure 1 graphically illustrates the improvement in both quality and depth of the mathematics preparation of the entering engineering freshman. In 1952 only 47.0 percent of the class presented the 3½ units of mathematics now required for entrance as compared with 88.8 percent in 1960. This improvement in depth of preparation has been continuously improving with each new engineering class since 1952.

Likewise, the quality of mathematics preparation has been improving as measured by the number of new students passing the Mathematics Placement Ex-

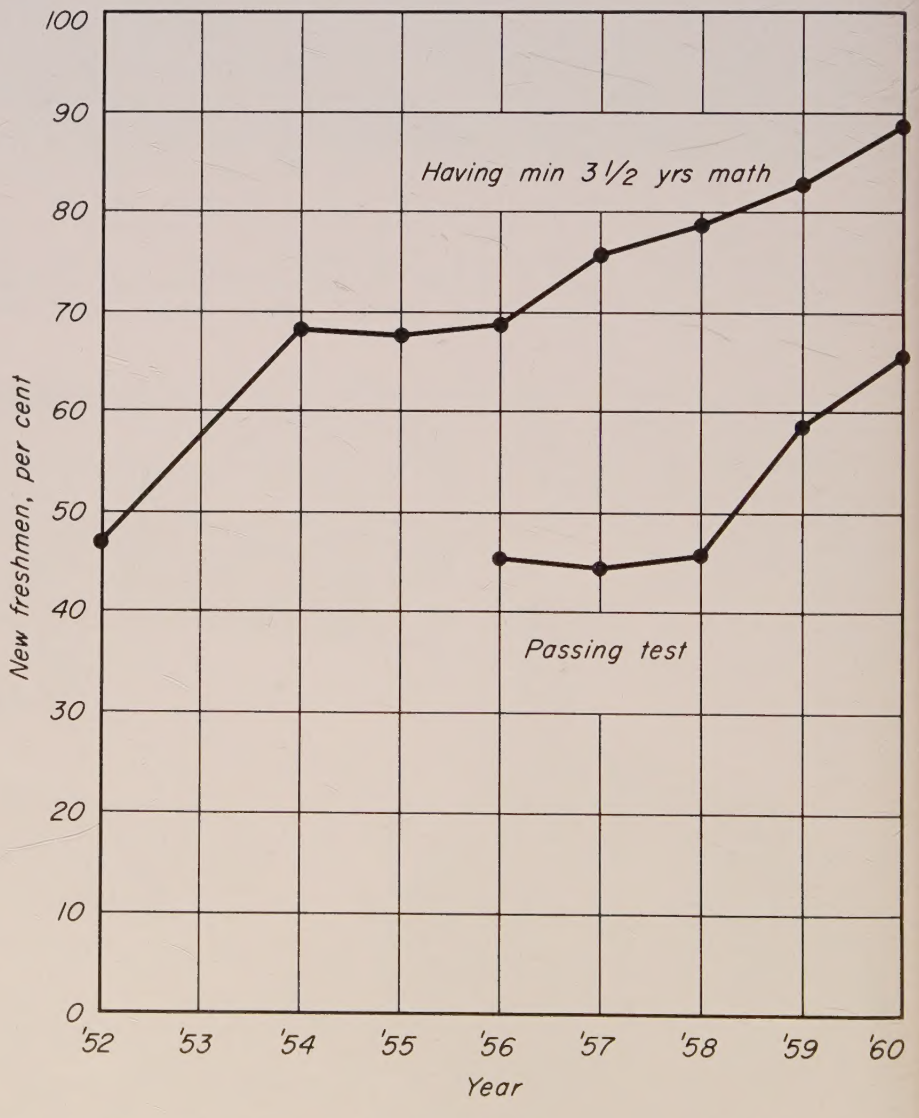


Fig. 1. New freshmen having 3½ units of mathematics required for entrance and percent passing mathematics placement test, College of Engineering University of Illinois.

amination. In 1956, 45.4 percent of those taking the examination passed as compared with 65.7 percent in 1960.

As students' mathematics preparation has improved, an interesting "by-product" has developed. Some of the more progressive high schools, realizing the advantage of advanced math programs, began to offer analytic geometry and calculus and a number of engineering freshmen now take integral calculus, differential calculus or differential equations, as their first mathematics course in the freshmen year. The number being placed in advanced math has increased each year as shown by the following table.

Number of New Freshmen placed in:

Year	1st calculus course	2nd calculus course	advanced calculus or differential equations
1953	7	2	2
1954	8	2	0
1955	9	1	0
1956	8	3	1
1957	7	2	1
1958	23	4	3
1959	26	6	3
1960	36	6	3

The number of freshmen placed in advanced mathematics in the Fall 1960 (45 students) represented roughly four percent of the freshman class and has also been increasing from year to year.

High School Rank

Another method of measuring the quality of incoming freshmen is by comparison of their high school rank. Figure 2 graphically illustrates the increase in the percentage of new freshmen coming from the upper ten percent and upper thirty percent of their high school classes. Though the percent of students coming from the upper portions of the high school classes have generally increased, the freshmen of 1958 rank highest on the basis of decile comparison.

In the Fall of 1963, the College of Engineering is again increasing its requirements for entrance and it is expected that this requirement will result in even a higher proportion of high ranking students.

While students high school class rank has been increasing, the number of students coming from the lower 30 percent of their high school class has been continually decreasing and in 1960 represented only 4.1 percent of engineering freshmen (See figure II).

Subject Matter Presented for Entrance

A third way in which the quality of the incoming class may be gaged is through a comparison of the number and quality of high school units offered for entrance. Recently a thorough comparative study was made of the engineering freshmen classes of 1954 and 1958. A comparison was made on the numbers of units of high school credit offered for admission by each class. In nearly every major subject considered, students had more high school preparation in 1958 than in 1954. A few of these comparisons below illustrate the changes from 1954 to 1958.

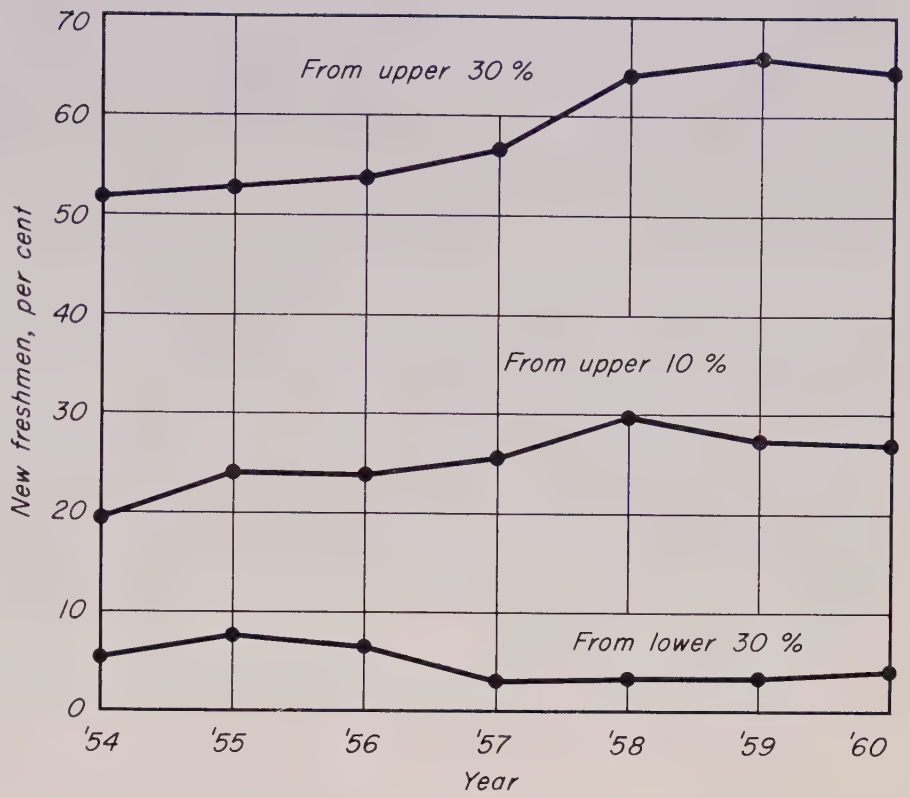


Fig. 2. High school class rank of new freshmen, College of Engineering University of Illinois.

New Freshmen Presenting at Least:	Percent of the Freshmen Class in the Fall 1954	Fall 1958
Three units of English	99.3%	99.5%
Four units of English	72.9%	82.1%
Two units of algebra	67.3%	86.2%
One unit of physics	83.0%	92.0%
One unit of chemistry	75.1%	87.7%
Two units of language	49.9%	55.2%
Two units of social studies	83.7%	80.6%

Only in the area of social studies was a decrease noted and though only three years of high school English are required for entrance, 82.1 percent of the freshmen had four units of credit in 1958.

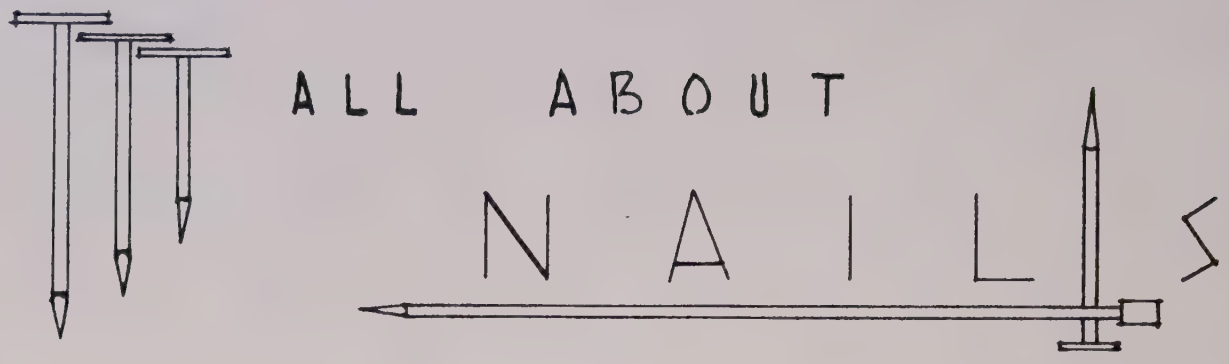
On the average, a freshman in 1958 had more units of total high school credit than a freshman in 1954. However, the total units of high school credit do not measure the quality of high school subject matter. Thus, a comparison was made of the academic studies taken (i.e. chemistry, mathematics, social sciences, language, and English). It was evident that the 1958 freshmen class presented a better background in academic subjects, since nine or more semesters of academic credit was presented by 30 percent of the 1958 class versus only 14.5 percent of the 1954 class. Some of these increases in units of credit presented may appear minute, but the fact that these increases were made in a short period of four years makes them quite significant.

The New Class

Returning to the original question asked, "How does the new freshman class look?", we have been able to answer for several years, "Better than the previous class!" Based on mathematics preparation, high school class rank, and high school subjects studied, there is no doubt that each succeeding freshman class has been better than the previous one for the last eight years.

The one variable which can not be measured though, is the quality of instruction at the high school level. However, there is no reason to expect that it has been on the decline and in the case of mathematics, the increasing percent of students passing the placement test would lead us to believe that instruction is better than in the past.

(Continued on Page 21)



Did you know that plain, ordinary nails were once used to cure fever and ward off evil spirits?

Or that people have been saying "hit the nail on the head" for at least 2,000 years?

Or, that your own house, if it's a typical frame building, is probably held together by at least 67,000 nails?

Nails are such a commonplace necessity of everyday life that hardly anybody realizes what a long and fascinating history they have.

The nail was invented all the way back in the Bronze Age—once men had learned to work metal, it didn't take them long to discover that small bits of it could be pounded into fasteners that were far superior to old-fashioned resin paste and leather thongs.

Some of the Bronze and Iron Age nails that have been found in Europe are merely pointed slivers, widened at the top, but others have mushroom-like heads and are practically identical to modern ones.

Nail-making was a flourishing industry in England during the Roman occupation in the 1st Century.

In the Orient, nails made of precious metals with decorative heads were used on religious monuments and on the furniture of the wealthy, hundreds of years before Christ.

King Solomon's throne, according to tradition, was studded with golden nails.

And in the Middle Ages, Europe, too, began to use nails for decoration. Nails with heads worked into elaborate star and flower designs, or shaped like animals and human faces, ornamented church and castle doors, locks and ironwork.

The harnesses and armor of medieval knights were often studded with nails bearing devices from the owner's coat of arms.

And the metal, leather or embroidered covers that protected precious hand-illuminated manuscripts had decorative nails down the edges to keep them from scuffing and tearing.

Decorative nail-making was popular throughout the Renaissance; it began to die as cutting machines replaced hand forging at the end of the 17th Century.

In America, cutting machines didn't come into general use until the 19th Century. And, since nails were in great demand in Colonial days, many farm families found that pounding them out by hand was a pleasant and profitable occupation during the long winters.

In the middle of the 19th Century, the invention of drawn wire revolutionized nail production. Drawn wire nails could be turned out so quickly and cheaply that they could be sold for hardly more than the price of the wire itself.

Over the past 100 years, nail manufacturers have concentrated on perfecting their product and developing new types of nails for special uses. There are over 400 kinds on the market today.

One of the newest is Jones & Laughlin's Ardox nail, with a spiral shank that turns like a screw when driven into wood, to reduce the danger of splintering. Oddly enough, although it is 30% easier to drive into wood, the Ardox holds nailed pieces together more solidly than any ordinary nail.

Most people use nails, of course, just for the practical purpose of holding things together, but over the centuries, many more interesting uses have been found for them.

The ancient Romans drove a nail into the wall of the Temple of Jupiter every year on the 13th of September, to tally the year and to ward off plagues and calamities during the months ahead.

The Roman scholar, Pliny, wrote that it was fatal to sleep under a yew tree unless a copper nail was driven into the trunk.

He also suggested treating epilepsy by driving a nail into the ground where the sick man had fallen, to capture the evil spirit that possessed him.

The belief that practically any kind of illness from a headache on up can be treated by "Nailing of Evils"—driving a nail into a tree trunk, wall, or any other convenient surface, and leaving the ailment behind, firmly nailed down—appears in folklore all over the world.

One old English recipe for curing the ague advises the sufferer to nail a lock of his hair to a tree and wrench the lock from his head.

Another, spookier but less painful, tells the patient to go to the crossroads at midnight, alone, and as the clock begins to strike, turn around three times and drive a tenpenny nail into the ground, then walk away from the spot backwards before the clock finishes the twelfth stroke.

In the Scottish Highlands, women in childbirth used to be protected from the elves by a row of iron nails on the front of the bed.

Nails keep popping up in the proverbs and similes of practically every language, too.

The Roman dramatist, Plautus, had a character exclaim, "You've hit the nail on the head," in 200 B.C.

The French story-teller, Rabelais, who may or may not have read Plautus, came up with a similar expression in the 14th Century, and 200 years later, Cervantes' Don Quixote said in Spanish, "I may at last hit the nail on the head." The phrase has been common in English since the 16th Centry.

The expression, "nail in your coffin" for any habit that actually or supposedly shortens life dates from the 18th Century, when the English writer, John Wolcot, decided that:

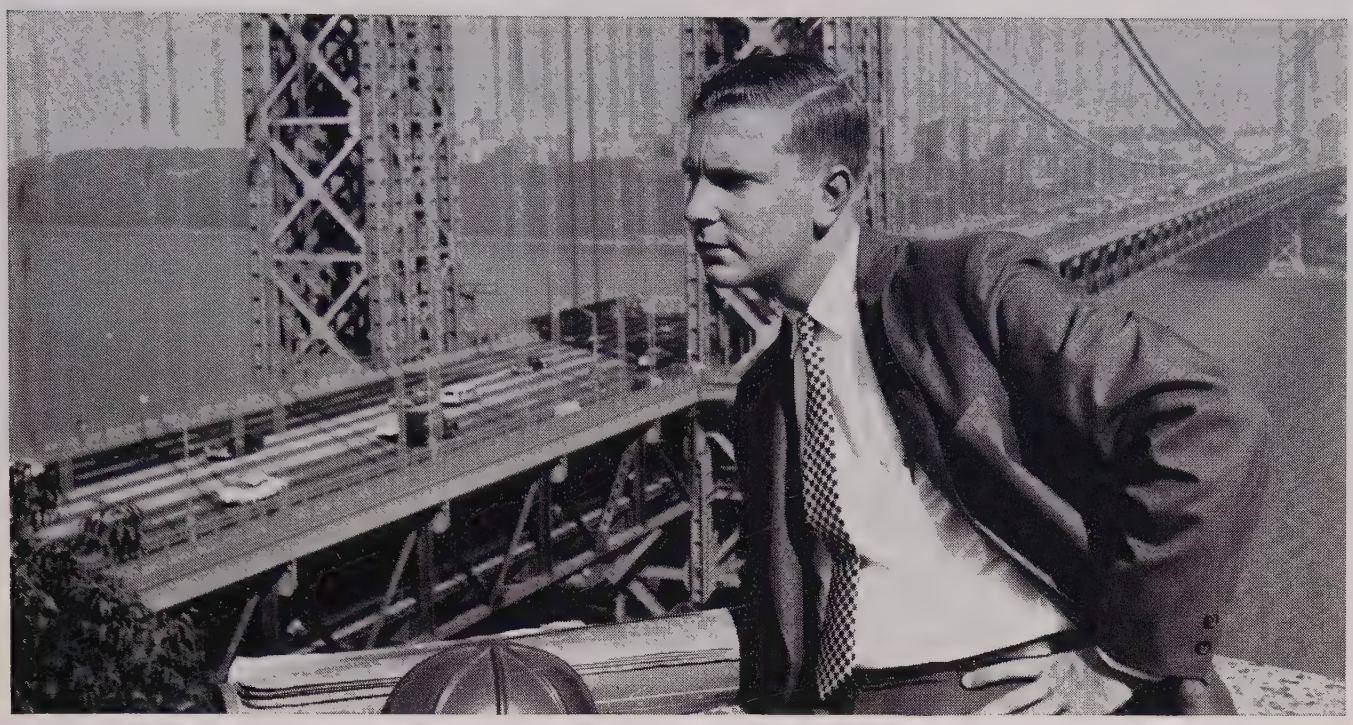
"Care to our coffin adds a nail, no doubt,
And every grin so merry drives one out."

"As dead as a doornail" first appears in the 14th Century, in William Langland's *Vision of Piers Plowman.*

And then there is the familiar nursery rhyme, known in a dozen different versions:

"For want of a nail, a shoe was lost,
For want of a shoe, a horse was lost,
For want of a horse, a rider was lost . . ."

Sometimes the rider who takes the fall turns out to be a king who was leading his army in battle, and the verse ends with the loss of battle and kingdom, "all for the want of a horseshoe nail . . ."—probably the most dramatic tribute paid to the nail in all its 5,000 years of useful life.



THIS YOUNG ENGINEER IS ON THE ROAD TO MANAGEMENT

Dick Cotton knew he wanted to take the engineering route into management long before he joined New Jersey Bell Telephone Company. In fact it was his goal when he was working for his engineering degree at Rutgers.

When he graduated, he had his lines out to eleven other companies. He came to New Jersey Bell because: "I didn't feel I was just a number to these people. There was no doubt in my mind that this job would be the best for the long pull."

His first assignment was a tough one. A complex of major telephone cables lay in the path of the approach to the new traffic level of the George Washington Bridge on the Hudson. Dick's job was to find the most practical and economical way to reroute these cables, and at the same time to provide for future telephone growth in the area around the bridge approach.

Dick ironed that one out and got a crack at another tough job.

Next stop: New Jersey Bell Headquarters Engineering Staff, Special Studies Group. Here Dick was a member of a four-man team whose job was to find ways to eliminate some of the routine work of field engineers to give them "more time to think." Dick also helped plan and control a $100,000,000 annual telephone construction budget.

Presently, Dick is responsible for telephone equipment engineering projects in the Camden, New Jersey, area.

How does Dick look at it? "This is a growing business. I work with this growth every day. And growth means more room at the top. Of course, I don't figure I'll get there overnight—but on my jobs so far I've had a chance to take a good look at how this business is run. And I think the sky's the limit for a man who really wants to work for it."

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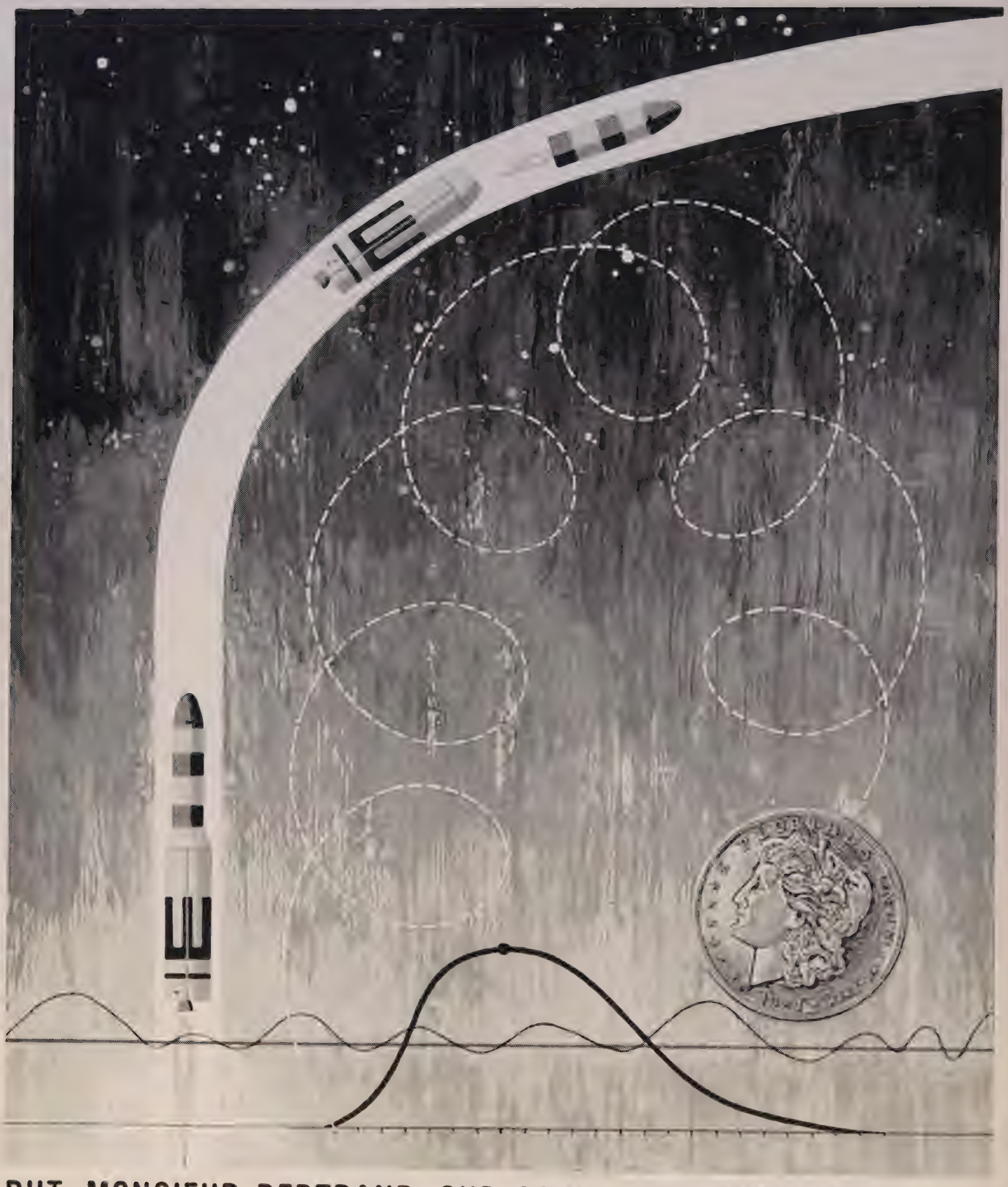

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May is the month for flowers and, better yet, our May Technocutie, 18-year-old Bonnie Phyllis Kamstock. The raven-haired beauty is experiencing her first year at the U. of I. and is enrolled in Elementary Education. Bonnie loves little children and is even hoping to be with them this summer working as a camp counselor. Chicago is her hometown, and she is now a resident of Allen Hall. By no amount of coaxing could we find any of her personal dislikes, but we did discover that she is particularly fond of drawing, dancing, and, of course, someone to dance with—particularly those special breeds of dancers sometimes referred to as ME's, EE's, CE's, etc. We saved the best for last and we'll let these vital statistics speak for themselves: 5'5", 120 pounds, 36"-22"-36".

Technocutie . . .

BONNIE KAMSTOCK

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PhD, MS in Physics and Mathematics
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We're not looking for a direct answer.

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Magnificent Miniatures, a 16mm color and sound film, pictures the manufacture and uses of MPB bearings. The new comprehensive MPB catalog with basic engineering information, describes the complete line and many applications. Both are available to your class or group, without charge, from Miniature Precision Bearings, Inc., 35 Precision Park, Keene, N. H.

MPB

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THE ROUNDHOUSE

James H. Stein, Jr., Tau Beta Pi

His grin, as usual, was wide and cynical, and his clear blue eyes were sparkling mischievously as he mentioned the Roundhouse. Several of his students caught the humor and laughed appreciatively. Dr. Engel had just announced a German midterm to be held in the University Auditorium.

I laughed at that gentle satire on

the Auditorium two years ago, but today it no longer strikes me as funny. Our Roundhouse is not a laughing matter; our need for a decent auditorium is too great, and the administration's concern too small.

The University of Illinois is one of the larger and better universities in the Midwest, an important center of learning and of culture. Nevertheless, when a leading French drama group visited the campus to perform a Molliere comedy, they were forced to perform without scenery. America's greatest baritone was recently asked to sing in concert to the accompaniment of a rasping air conditioner. Some of the world's finest orchestras have played here, either in the huge, boxy gymnasium where the delicate melodies of the strings cannot carry, or in the misproportioned pillbox where acoustical demons slay the woodwinds.

All these atrocities are sanctioned by a university administration which either can not, or will not, provide the campus with the cultural center it so sorely lacks: a concert hall.

The University Auditorium acoustics are admittedly bad. Some members of the audience are beseiged by echoes, others cannot hear at all. Needless to say, the conditions in Huff Gym are no improvement. A Chicago columnist heard the Philadelphia Orchestra perform here, then returned home to write of the university's "medieval concert facilities."

Stage equipment at the auditorium is also at a minimum. Performers' managers are invariably amazed that a concert hall could be so completely barren. There are no battens, poles, rigs, lights or wings, nor is there any feasible way to install them. The only curtain (a deep brown which mismatches the red velvet backdrops) is an earsore as well as an eyesore. Its schrill squeaks spoiled every dramatic climax staged by a Spanish dance group here recently.

These conditions work a double hardship on the Star Course in its attempts to present as wide a variety of superior talent as possible. First, the lack of facilities excludes even the thought of bringing a full scale opera or ballet to campus. The performers wouldn't and couldn't perform. Second, the continuing and increasing antipathy of the public towards the worse-than-archaic facilities (small European villages had better concert halls two centuries ago) has led to a decline in attendance of musical events over the past few years. As a result, stars who repeatedly sell out larger concert halls at smaller colleges than here often play to a half-empty house at Illinois. This means less revenue for the Star Course, and thus some superior attractions cannot be booked. The public is the loser.

Still, the administration apparently ignores the community's need for adequate concert facilities to replace the pathetic auditorium. It was the realization of this tragic situation which caused my German teacher to scorn our "concert hall" two years ago. I now wonder whether Dr. Engel is not more accurate and less facetious in calling the auditorium a round house, than is the administration in calling the roundhouse an auditorium.

Controlled Nuclear Fusion

By George Carruthers, N.E., B.S.Aero.E.

The first three articles of the series have shown many possible applications of nuclear fission. Although seemingly inexhaustible, however, the world's supply of fissionable material is really quite limited, and before long man will have to turn to some other source of power. It is in controlled fusion, the power source of the sun and stars, that lies promise of the ultimate power supply.

At present, the world power consumption is 0.1 Q per year, where one Q is 10^{18}BTU. By the year 2000, we will be using 1 to 2 Q per year—approximately an exponential increase. The total world reserve of fossil fuels is estimated to be only 35-40 Q, therefore, if coal, oil, etc. were the only source of power, we would be in danger of running out before long. In addition, there are many uses of coal and oil in the chemical industry for the manufacture of plastics, dyes, drugs, etc. which would be endangered by the continued use of these raw materials as fuels.

The additional benefit obtainable from the use of U-235 in nuclear power reactors is slight, because the world reserve of this fissionable uranium isotope is only about 13 Q. However, if the U-235 were used in breeder reactors, which convert non-fissionable U-236 into plutonium as well as produce power, the total fission power available (corresponding to complete consumption of U-238 as well as U-235) rises to 2000 Q. Even this, however, would not last indefinitely.

If we consider the use of deuterium, the heavy isotope of hydrogen, as the fuel for a thermonuclear reactor, we find that there is enough deuterium in ocean water to provide about 10^{11} Q—enough to supply the world's needs for an indefinite period of time. Therefore, much research is being done throughout the world in an attempt to tame the fusion reaction. The United States effort along these lines, Project *Sherwood*, was begun in 1952 and has contributed much new knowledge of the basic principles of controlled fusion technology.

The Process of Nuclear Fusion

It was shown in the first article of the series that the graph of binding energy per nucleon (energy required to break the atom up into its constituents, divided by its mass number) started out from zero for hydrogen, reached a maximum in the region of Iron (A = 50) and then gradually decreased toward the heavier nuclides. Nuclei tend to reach equilibrium at the point of maximum binding energy; that is, the heavier nuclei tend to break up into lighter parts close to the maximum of the curve, with a release of energy equal to the difference in the total binding energy (fission of U-235, for example), while the lighter nucleon tend to combine, or fuse, to make atoms of intermediate weight, also with the release of energy. In fusion reactions, the energy release per nucleon is usually greater than in fission reactions, because the differences in binding energies are much greater in the light nuclides than in the very heavy ones.

The fusion reaction is known to be the source of energy in the sun and other stars. In the center of the sun, and in the hotter stars, the primary source of energy is believed to be the so-called "carbon cycle," in which carbon acts as a sort of catalyst for the combination of four hydrogen atoms to form a helium atom.

CARBON CYCLE

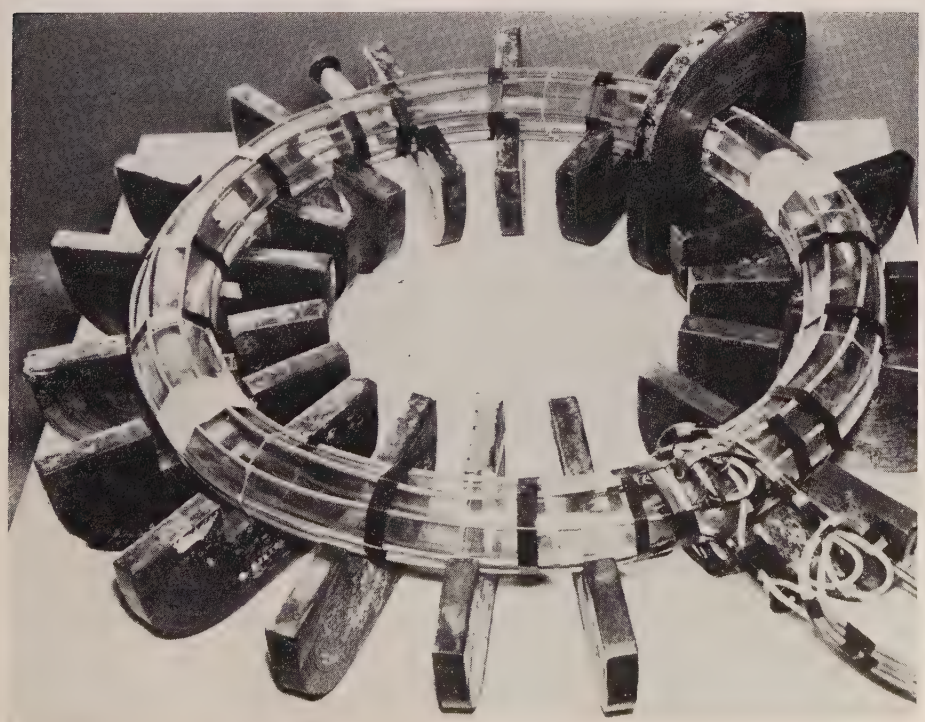
$$_1H^1 + {}_6C^{12} \rightarrow {}_7N^{13} + \gamma$$
$$_7N^{13} \rightarrow {}_6C^{13} + {}_0e^{+} + \nu$$
$$_1H^1 + {}_6C^{13} \rightarrow {}_7N^{14} + \gamma$$
$$_1H^1 + {}_7N^{14} \rightarrow {}_8O^{15} + \gamma$$
$$_8O^{15} \rightarrow {}_7N^{15} + {}_0e^{+} + \nu$$
$$_1H^1 + {}_7N^{15} \rightarrow {}_6C^{12} + {}_2He^{4}$$

(γ = GAMMA RAY; ν = NEUTRINO)

In the outer parts of the sun, and in the cooler stars, the direct proton-proton chain is believed to be the primary source of energy. In both reactions, the net reaction is the combination of four hydrogen atoms to form one helium

PROTON-PROTON CHAIN

$$_1H^1 + {}_1H^1 \rightarrow {}_1H^2 + {}_0e^{+} + \nu$$
$$_1H^1 + {}_1H^2 \rightarrow {}_2He^{3} + \gamma$$
$$_2He^{3} + {}_2He^{3} \rightarrow {}_2He^{4} + {}_1H^1 + {}_1H^1$$



"Perhapsatron" experimental pinch tube

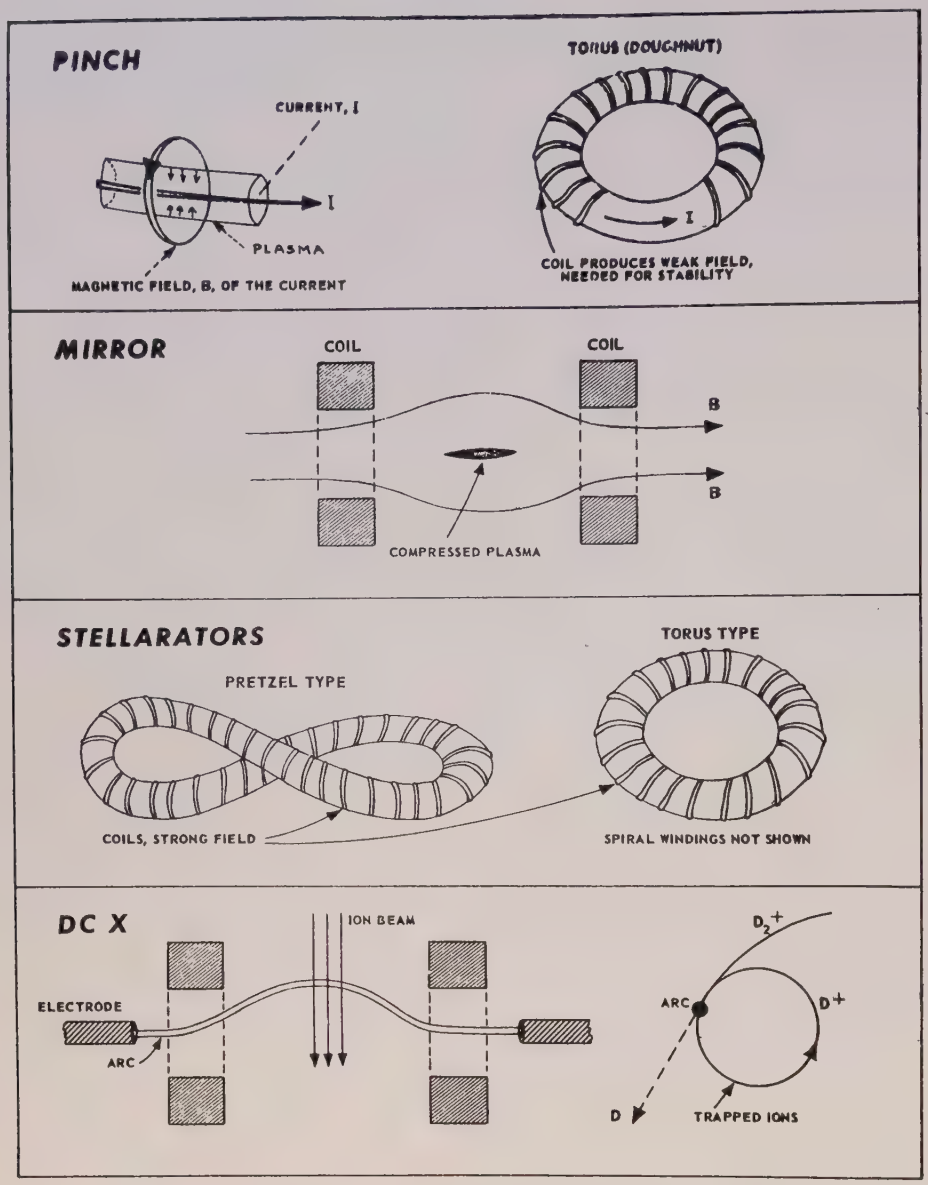
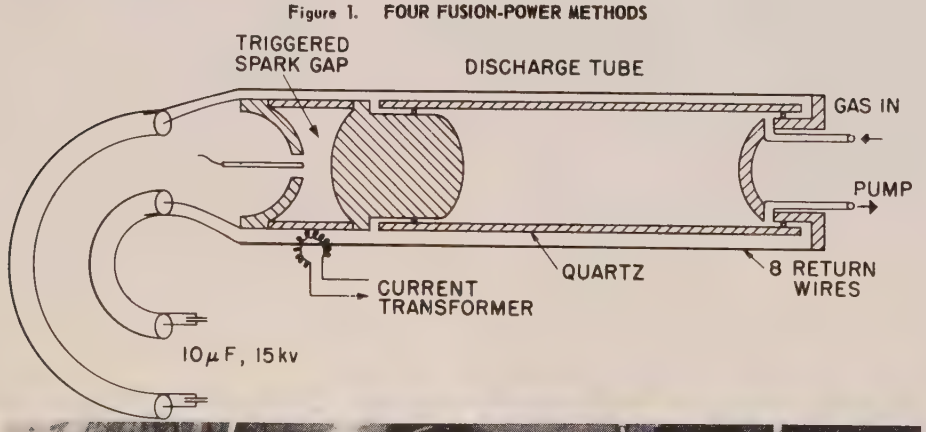


Figure 1. FOUR FUSION-POWER METHODS



The "Columbus" linear pinch tube

atom with the release of 26.7 Mev of energy.

Neither of these reactions would be practical on earth, because the reaction cross sections are very small and the rate of reaction is so slow that tremendously large volumes and very high pressures would be resuired, in addition to very high temperature, for the production of any appreciable power. The reason for the slowness of these reactions is the necessity of a beta-decay process, in which a positron and neutrino are emitted, before protons can be made to combine.

Some thermonuclear reactions appear feasible on earth. The secondary reaction is also important, in that if a thermonuclear reactor were to be surround-

POSSIBLE FUSION REACTIONS

$$_1D^2 + {}_1D^2 \begin{cases} \rightarrow {}_2He^3 + {}_0n^1 + 3.27 \text{ Mev} \\ \rightarrow {}_1T^3 + {}_1H^1 + 4.03 \text{ Mev} \end{cases}$$

$$_1D^2 + {}_1T^3 \rightarrow {}_2He^4 + {}_0n^1 + 17.6 \text{ Mev}$$

SECONDARY REACTION

$$_3Li^6 + {}_0n^1 \rightarrow {}_2He^4 + {}_1T^3 + 4.6 \text{ Mev}$$

NET REACTION

$$_3Li^6 + {}_1D^2 \rightarrow {}_2He^4 + {}_2He^4 + 22.2 \text{ Mev}$$

ed by a lithium jacket, not only would additional power be generated but the expensive tritium would be regenerated, and could be separated for re-use in the reactor.

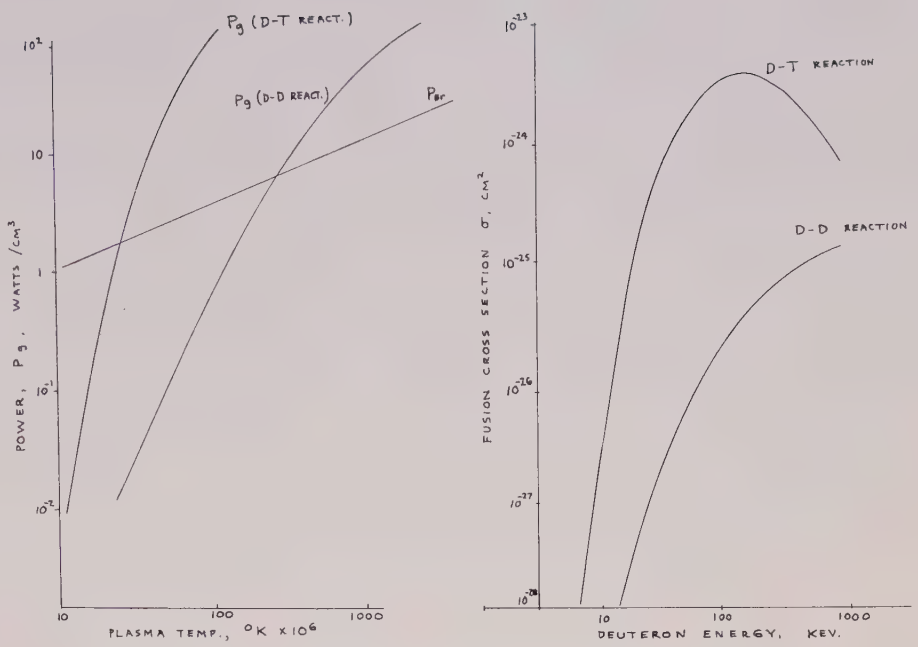
In the hydrogen bomb, the direct Li-D reaction is believed to occur. The H-bomb uses an ordinary fission bomb as a "trigger" which, creating temperatures on the order of 10^8 °K, starts the fusion reaction in a jacket of lithium deuteride surrounding the trigger.

Very high temperatures are needed for the initiation of fusion reactions, because of the Coulomb repulsion existing between the positively charged nuclei. The energy required to surmount the Coulomb barrier and allow the nuclei to fuse together is of the order of one Mev. According to the kinetic theory of gases, however, the energies of the molecules of a gas follow a Maxwell-Boltzmann distribution, in which a few of the gas molecules have energies much greater than the average kinetic energy of the molecules. Therefore, if a gas is heated to a temperature of 10^8 °K, although the average particle energy is only 10,000 electron volts (1 e.v. = 10^4 °K) there are always a few nuclei which have enough energy to cause fusion reactions, with energy release depending on the energy and cross section of the reaction.

At the temperatures of interest in thermonuclear reactions, the lighter atoms such as hydrogen and helium are totally ionized. This is fortunate in that

the ionized gas, or *plasma*, no longer followeds the Stefan-Boltzmann law for black-body radiation in which the power radiated is proportional to the fourth power of the absolute temperature. Instead, the radiation is mostly in the form of *bremstrahlung*, or "braking radiation," a type of continuous X-radiation caused by the deceleration of electrons in the electric fields of the positive nuclei. This radiation is proportional only to the square root of the temperature. If the plasma is contaminated by atoms of heavier elements, these heavy atoms retain some electrons and emit a black-body spectrum which increases tremendously the radiative power loss of the plasma; it is very important to keep the plasma free of all impurities.

As may be seen from the graph, rate of power generation exceeds radiation losses at about 45 million degrees for the D-T reaction and 400 million degrees for the D-D reaction. Reaction cross sections as a function of temperatures are also shown.

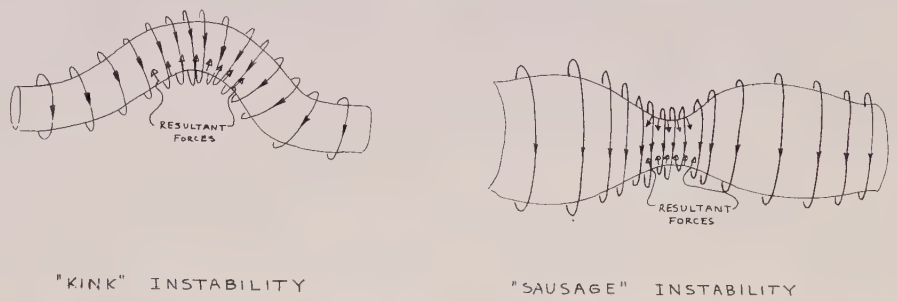


Power output and cross section curves for fusion reactions

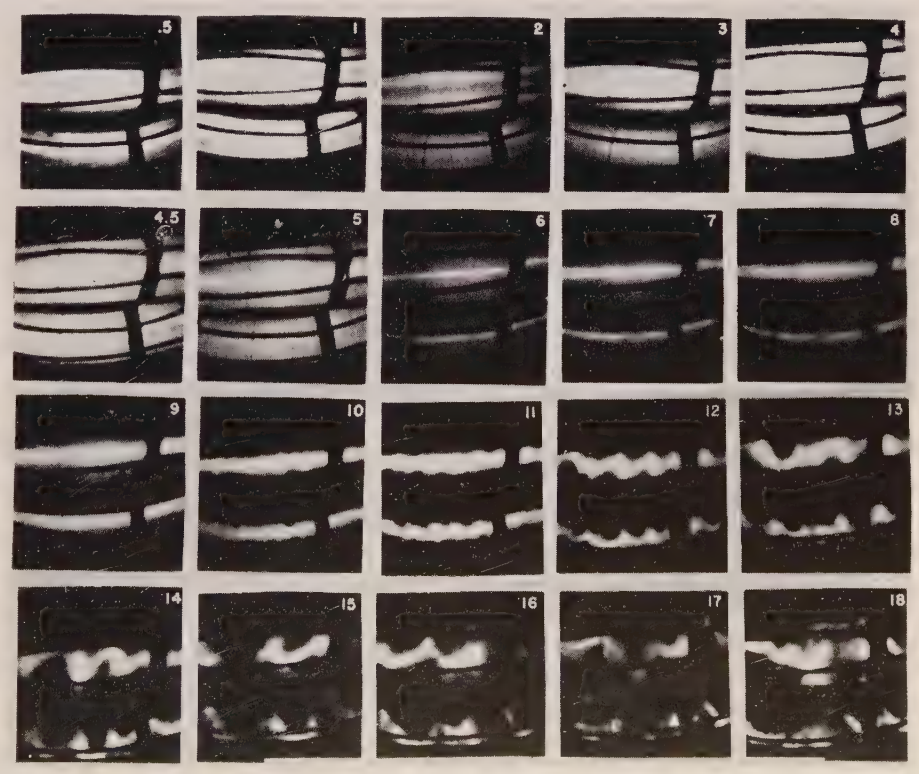
Controlled Thermonuclear Devices

Because of the extremely high temperatures of thermonuclear reactions, and the need for high purity of the plasma, the only practical means for the confinement of the reaction is the use of magnetic fields. The basic laws governing the interaction of magnetic fields with an electrically-conducting plasma are based on Maxwell's equations, the Lorentiz force equation, and other equations of electrodynamics, as well as the ordinary equations of gas dynamics and hydrodynamics. This combination of electrodynamics and fluid dynamics forms the new science of *magnetofluiddynamics*, or plasma dynamics. One of the first major efforts of the Sherwood project was to gain a basic understanding of plasma dymnacic processes.

One of the first methods for confining and heating a plasma to thermonuclear temperatures which was investigated was what is known as the *pinch effect*. The pinch effect, discovered in early experiments with electric arcs, is an application of the fact that conductors which are parallel and carry current in the same direction attract each other. In an electric arc discharge, the flow of current in one part of the discharge exerts an attractive force on the current in another part, with the result that the plasma column is "pinched" into a very slender cylinder. The magnetic pressure, Pmag., is proportional to to the square of the current. The decrease in cross-sectional area of the plasma column results in an increase in current density and therefore an increase in temperature. To produce a temperature of 10^8 °K under typical pinch conditions requires a current of



Two basic types of plasma pinch instabilities



Life and death of a pinch in the Perhapsatron tube. Time from start of discharge is in microseconds.

MAXWELL'S EQUATIONS

CONSERVATION LAWS $\nabla \cdot \vec{B} = 0$

$\nabla \cdot \vec{E} = \frac{\rho_e}{\epsilon_0}$

$\nabla \cdot \vec{J} = -\frac{\partial \rho_e}{\partial t}$

AMPERE'S LAW $\nabla \times \vec{B} = \frac{1}{\mu_0}\left[\vec{J} + \epsilon_0 \frac{\partial \vec{E}}{\partial t}\right]$

FARADAY'S LAW $\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$

OHM'S LAW $\vec{J} = \sigma(\vec{E} + \vec{v} \times \vec{B})$

LORENTZ FORCE $\vec{F} = \vec{J} \times \vec{B} = \sigma(\vec{E} + \vec{v} \times \vec{B}) \times \vec{B}$

CONTINUITY EQN. $\nabla \cdot \rho \vec{v} = -\frac{\partial \rho}{\partial t}$

B = magnetic field strength
E = electric field strength
e = electronic charge
F = force
J = current density
k = Boltzmann's constant
m = mass of particle
N = # particles /cc.
n = # electrons /cc
n_0 = total # molecules
P = power
R = radius of nucleus + incoming particle
r = radius from ctr. of nucleus
v = velocity
T = temperature
Z = atomic number
ϵ = emissivity
ϵ_0 = dielectric constant
μ = 0.51 Mev
μ_0 = magnetic permeability
ρ = density
ρ_e = charge density
σ = Stefan-Boltzmann constant

COULOMB BARRIER POTENTIAL

$$U = \int_{\infty}^{R} \vec{F} \cdot d\vec{r} = \int_{\infty}^{R} -\frac{Z_1 Z_2 e^2}{r^2}\, dr = \frac{Z_1 Z_2 e^2}{R}$$

BLACK-BODY RADIATION LAW

$$P_R = \epsilon \sigma T^4$$

BREMSSTRALUNG RADIATION

$$P_{BR} = \frac{3.09 \times 10^{-27}\, Z^2\, n\, N\, 4\pi\, \mu\, m^{3/2}}{(2\pi\, kT)^{3/2}} \int_0^{\infty} v^3 e^{-\frac{mv^2}{2kT}}\, dv$$

$$= \frac{8.75 \times 10^{-27}\, Z^2\, n N \mu \sqrt{kT}}{\sqrt{\pi m}}$$

MAXWELL-BOLTZMANN DISTRIBUTION

$$n(v) = 4\pi n_0 \left(\frac{m}{2\pi kT}\right)^{3/2} v^2 e^{-\frac{mv^2}{2kT}}$$

MAGNETIC PRESSURE

$$P_{mag} = \frac{B^2}{8\pi}$$

Basic equations of thermonuclear physics

over a million amperes. Currents of this magnitude can be produced only for short periods of time, through the use of condenser bank discharges. Therefore, all work of this type has necessarily been with "pulsed" operation, with maximum discharge times of the order of a few milliseconds.

One of the first devices used in the investigation of the pinch effect for use in thermonuclear reactors was the Perhapsatron. In this device, a toroidal discharge tube filled with low-pressure gas served as the secondary winding of a transformer, the primary of which was a few turns of wire along the surface of the tube. When the primary windings were energized by a condenser discharge, a high current discharge was included in the gas in the tube. The discharge rapidly pinched down to a thin filament, but was quickly destroyed by instabilities.

It was though that part of the instability problem might be caused by the fact that the magnetic field varies from the inside to the outside radius of the discharge tube. Therefore, a figure-8 type configuration, the Stellarator, was built and tested. Although much useful data was obtained, this did not fully solve the instability problem.

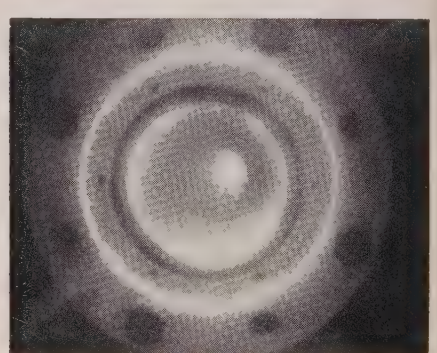
It was found that there are two basic types of pinch instability. The first, known as "kink" instability, results from the fact that, when there is concave curvature in the plasma, the magnetic field lines are bunched together, resulting in a force which tends to increase the curvature, and so on. The second type, known as "sausage" instability, results from the fact that the field strength is greatest where the pinch is narrowest, which tends to decrease the diameter, etc. with the result that the plasma is actually pinched in half like a sausage. It was discovered that the pinch might be stabilized by the use of a longitudinal magnetic field which would act as a sort of "backbone" to the plasma. It was discovered that, using the superimposed magnetic field, that the cylindrical and torodial type discharge tubes were just as good as the pretzel-shaped Stellarator, with the result that the latter project was discarded. One of the experiments along these lines is the Columbus device.

In all of the devices using the pinch effect, it was very difficult to get temperatures high enough for any observable thermonuclear reactions to take place. The reason for this was that, as the gas in the pinch was heated, its conductivity increased so greatly that, beyond a certain point, the resistance was difficult to add any further energy to the gas. Therefore, other means for heating the gas were investigated.

At Oak Ridge, work was done in the Molecular Ion Ignition experiment, known as DC-X. In the DC-X device, a high-intensity carbon arc was established along the lines of a magnetic field. Molecular deuterium ions (D^+_2) were shot into the arc from a direction perpendicular to the magnetic field by a 600-Kev accellerator. When the molecular ions passed through the arc, they were dissociated. The neutral deuterium atoms then passed out of the field while the deuterium ions were trapped in the field and formed a circulating ring current, which theoretically could be made to have thermonuclear temperatures.

At Los Alamos, the concept of Magnetic Compression was investigated. In a device known as Scylla, a cylindrical discharge tube was surrounded by a flat turn of copper which, when connected to a condenser bank, not only heated the gas to extreme temperatures but created a magnetic field which compressed the plasma to a very small volume. In the Scylla III device, an ion temperature of 36 million degrees was obtained using a maximum field strength of 115,000 gauss. 50 million neutrons, undoubtedly of thermonuclear origin, were produced during the microsecond-long discharge.

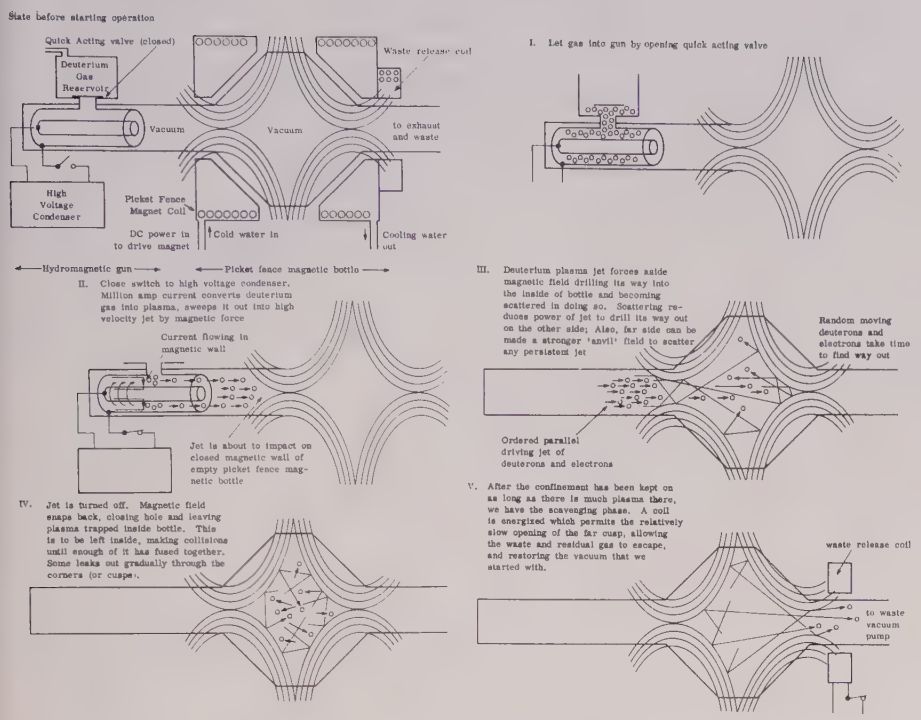
Another concept being investigated is that of the "magnetic mirror" or "magnetic bottle." If a magnetic field is made stronger at both ends of a discharge



"Scylla III" in operation

tube, the plasma tends to be trapped in the region between of lower field strength. By use of various arrangements of field coils, the plasma can be compressed into smaller and smaller "bottles," thereby possibly obtaining thermonuclear temperatures. Efforts in this direction are Table Top and Toy Top magnetic mirror machines.

It can be shown theoretically that a plasma tends to be unstable if the magnetic field is concave inward, as in the magnetic bottle. However, it tends to be stable if the field is concave outward. One of the projects being investigated at Los Alamos utilizing this concept, is the Entropy Trap. In this device, high-velocity plasma is shot into a magnetic "picket fence" which traps the plasma, converting its kinetic energy into thermal energy. As yet, no attempts have


State before starting operation
Quick Acting valve (closed)
Deuterium Gas Reservoir
Waste release coil
Vacuum
Vacuum
to exhaust and waste
High Voltage Condenser
Picket Fence Magnet Coil
DC power in to drive magnet
Cold water in
Cooling water out
I. Let gas into gun by opening quick acting valve
Hydromagnetic gun
Picket fence magnetic bottle
II. Close switch to high voltage condenser. Million amp current converts deuterium gas into plasma, sweeps it out into high velocity jet by magnetic force
Current flowing in magnetic wall
Jet is about to impact on closed magnetic wall of empty picket fence magnetic bottle
III. Deuterium plasma jet forces aside magnetic field drilling its way into the inside of bottle and becoming scattered in doing so. Scattering reduces power of jet to drill its way out on the other side; Also, far side can be made a stronger "anvil" field to scatter any persistent jet
Random moving deuterons and electrons take time to find way out
Ordered parallel driving jet of deuterons and electrons
IV. Jet is turned off. Magnetic field snaps back, closing hole and leaving plasma trapped inside bottle. This is to be left inside, making collisions until enough of it has fused together. Some leaks out gradually through the corners (or cusps).
V. After the confinement has been kept on as long as there is much plasma there, we have the scavenging phase. A coil is energized which permits the relatively slow opening of the far cusp, allowing the waste and residual gas to escape, and restoring the vacuum that we started with.
waste release coil
to waste vacuum pump

The principles of "Entropy Trapping"

been made to obtain thermonuclear reactions with this device.

At the present time, it appears that thermonuclear power is *not* just around the corner. It will be at least ten to twenty years before thermonuclear devices become operational. In many early experiments with pinches, it was thought that thermonuclear reactions were obtained because bursts of neutrons were detected just before the pinch was destroyed by instabilities. However, it was found that the neutrons were not due to true thermonuclear reactions, but to collisions of deuterons accelerated by the strong electric fields existing at the point of onset of a sausage-type instability. Although neutrons of later experiments have been shown to be of thermonuclear origin, the durations of the discharges are much too short to permit production of useful power. The instability problem is still not completely solved.

In an operational thermonuclear reactor, it may be possible to generate electric power by direct interaction of the plasma with magnetic fields, thereby eliminating the heat-exchange cycle of the fission reactor power plant. An operational reactor would almost certainly be very large, and probably a few such power plants would serve the entire nation's needs for electric power.

Another field in which thermonuclear power would be very useful is in rocket propulsion. Assuming that the confining coils can be cooled sufficiently to handle the radiative heat transfer, it is theoretically possible to build a thermonuclear rocket with 2000-3000 seconds specific impulse with thrust-to-weight ratio comparable to that of chemical rockets. This would make true the science-fiction-story spaceship capable of going from the Earth to Mars and back, with landings at both ends, using only a single stage. Alternately, if the hot plasma itself could be used as working fluid instead of transferring heat to a secondary fluid (the "leaky bottle"), up to 350,000 sec. could be obtained, with a much lower thrust-to-weight ratio.

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3. Stephenson, R., *Introduction to Nuclear Engineering,* McGraw-Hill Book Company, New York, 1958.
4. Clauser, M., *Plasma Dynamics,* Addison - Wesley Publishing Corp., 1960.
5. Corliss, W., *Propulsion Systems for Space Flight,* McGraw-Hill Publishing Corp., 1960.
6. Prof. M. Wyman, Dept. of Nuclear Engineering, Univ. of Illinois.

Optical Study of Supersonic Boundary-Layer Transition

Microsecond - delay schlieren photographs of supersonic boundary-layer transition taken at the National Bureau of Standards provide definite optical evidence that boundary-layer transition processes in a supersonic air stream are similar to those in a subsonic stream. The photographs were taken using an unusual cylindrical-lens camera designed and constructed at the Bureau.

DEAN'S PAGE . . .

(Continued from Page 9)

The new entrance requirements for the College of Engineering, which go into effect in the Fall 1963, will probably raise the level of preparation and ability of the freshman class even higher than at present. The new entrance requirements for freshmen coming from high schools call for 3 units of English, 2 units of algebra, 1 unit of plane geometry, ½ unit of trigonometry, 2 units of science, 2 units of social studies and 2 units of foreign language. The two units of science must be selected from the areas of chemistry, physics or biology.

With this forthcoming change in entrance requirements and a continual reevaluation of entrance and degree requirements, the College of Engineering is confidently looking forward to a continual increase in the quality and preparation of entering students.

X-Ray Barrier Determinations

Measurements made by the National Bureau of Standards indicate that the calculated thickness of X-ray barriers may often be excessive. This conclusion, based on data collected in hospital and clinic X-ray rooms, may result in savings in the cost of future installations.

Glycerine in Ravioli? Why not?

In patent No. 2,950,978 issued August 30th, 1960, glycerine finds use as a plasticizer in a staple of the Italian cuisine—ravioli.

Glycerine, in a quantity ranging from 3 to 15% based on dry weight of the flour used, is incorporated in the dough during its initial mixing to prevent cracking of individual ravioli after drying.

According to the inventor, advantages of glycerine for this application are the following: it is water soluble, completely digestable and totally unaffected by elevated drying and water-boling temperatures.

Aluminum Engine for '61 Lancer

A six-cylinder engine with an aluminum block is now available in the 1961 compact Dodge Lancer, Dodge General Manager Byron J. Nichols announced recently.

The new cylinder block is die-cast, Nichols said, and is offered only with the 145-horsepower, 225-cubic-inch six-cylinder engine.

Several thousand Lancers with the 225 aluminum engine are presently in dealers hands, he revealed.

The aluminum block reduces the weight of the engine by almost 65 pounds. A six-cylinder engine with cast-iron block weighs 413 pounds.

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IN THE ROUND

Going around in a circle doesn't make you a square. At least that's the idea of Architect Orville Bauer who put this geometric figure to unusual architectural use in designing an exciting new circular home that has a view from every window and a new degree of compactness, space and livability.

His blueprint for comfort and gracious living may suggest ways for other homeowners to build better dream houses.

The site selected for the Bauer home was a rounded hilltop overlooking the picturesque panorama of Toledo's Maumee River Valley. To make the view an integral and dramatic part of the design and decoration of his hilltop home, Architect Bauer devised a plan of two circles with circular perimeter walls of glass that give the home an airy, spacious feeling in every room and untiring treetop beauty that changes with every season.

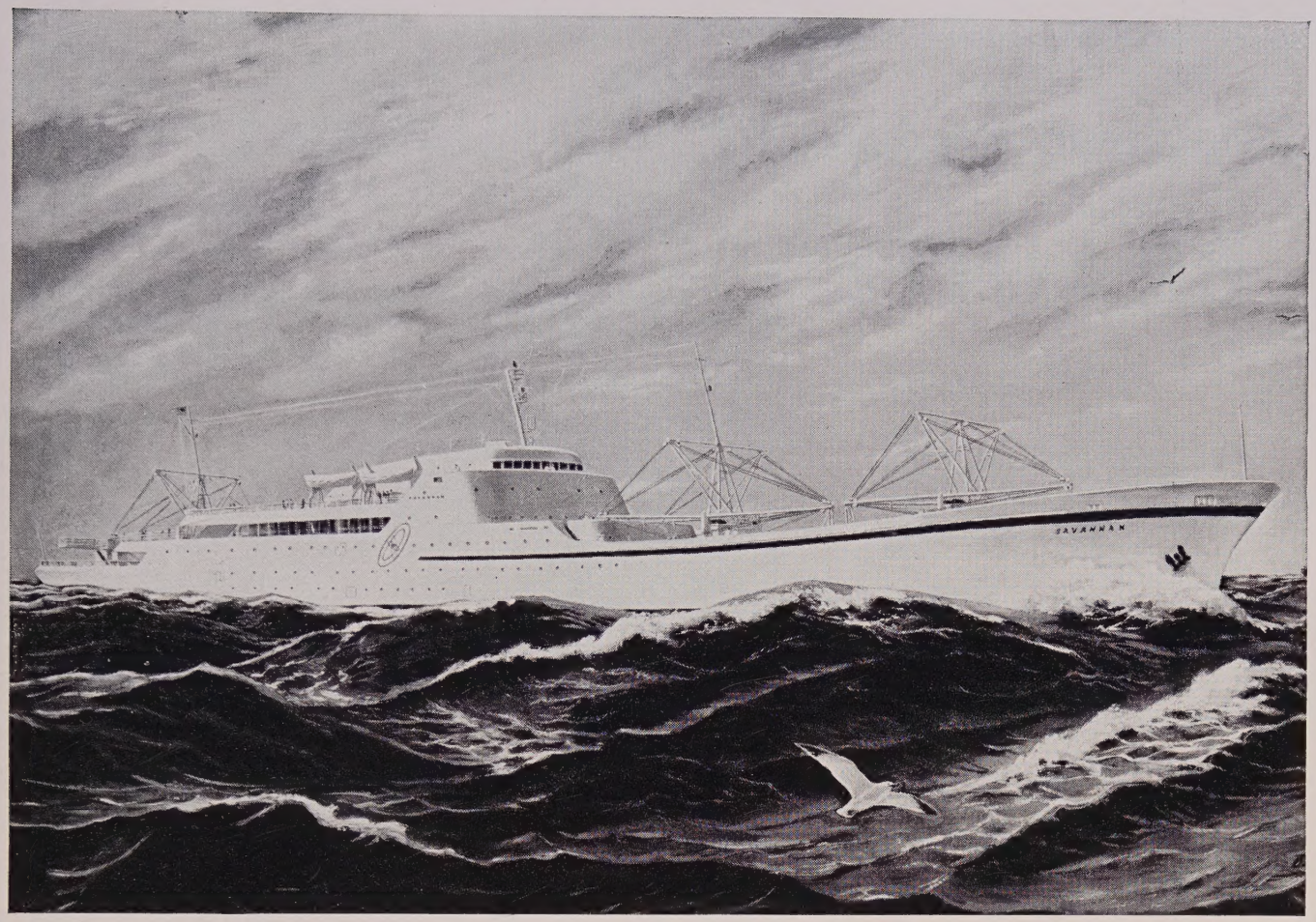
The main circle (see diagram), which is 46 feet in diameter, nestles into the rounded bank of the hillside while the other smaller circle, which is 25 feet in diameter, is suspended on slender but strong steel columns for a genuine tree-house effect. The circles are connected by an eight-by-eight-foot entrance corridor that provides access to both levels of the house.

In the main or "living" circle, the over-all plan is designed for privacy and convenience. This circle contains a master bedroom joining a bathroom, powder room and paneled den, two large bedrooms and private bath for the Bauer children, and a kitchen and dining area. In the children's rooms a folding door, used to separate the rooms at night, is opened in the daytime to provide a large play area. Each room contains spacious closets and adjustable shelves for clothing and storage. Entrance to this circle is made from the main corridor to either the paneled den or the kitchen-dining area.

The second smaller circle, which is the only truly circular room in the house, is the living room. It has a ten-foot-high ceiling, as compared to conventional eight-and-one-half foot ceilings in the rest of the house to provide the maximum spacious feeling desired. A large, crescent-shaped fireplace, built of the same native Ohio fieldstone used on the house foundation, acts as anchor for the living room.

This room, which is suspended above a concrete porch on the lower level, is of steel frame for structural support. Its view is the private world of treetops, seen through a circular wall of ceiling-high, eye-level windows. Here, as in other window areas, a special double-

(Continued on Page 24)



The Nuclear Ship Savannah is capable of sailing 350,000 nautical miles without refueling. Her uranium oxide fuel is packaged in tubes of Nickel Stainless Steel, more than 5,000 of them. In all, engineers specified 200,000 pounds of Nickel Stainless Steel for use in the ship's reactor... to meet the demands of high operating pressures and temperatures, and to provide much-needed strength and corrosion resistance in this critical application.

How Inco Nickel helps engineers make new designs possible and practical

When you design equipment, you'll have to select materials to meet given service conditions — materials that might have to resist corrosion, wear, high temperatures, or fatigue. Over the years, Inco has developed new alloys and gathered information on the performance of materials under these and many other service conditions. Inco will be glad to put this data at your disposal to help solve your future metal problems.

Inco's List "A" contains descriptions of 200 Inco publications which are available to you, covering applications and properties of Nickel and its alloys. For List "A", write Educational Services.

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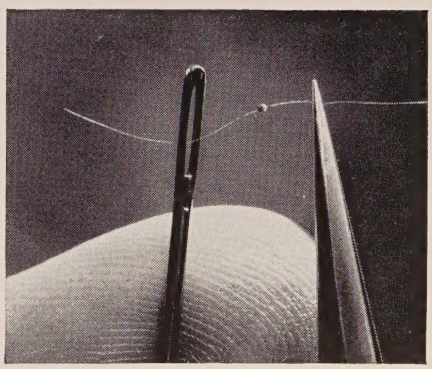
New push-button roof of Nickel Stainless Steel turns a weatherproof auditorium into an open-air stadium in a matter of seconds. The dome will provide years of carefree beauty. That's because stainless steel with Nickel in it is one of the most durable of metals. It's corrosion-resisting all the way through.



Needle's eye reveals relative size of a Thermistor, a tiny bead made with Nickel oxide—used to measure temperatures in and beyond the earth's atmosphere. The Nickel oxide helps develop electrical properties for the accurate recording of temperature changes as small as 1/50th of a degree!

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Technograph

BRAINTEASERS

By Ernie Frankovich

In a suburban home live Abner, his wife Beryl and their three children, Cleo, Dale and Ellsworth. The time is 8 p.m. on a winter evening. Can you tell who or who is not watching television.

1. If Abner is watching television, so is his wife.
2. Either Dale or Ellsworth, or both of them, are watching television.
3. Either Beryl or Cleo, but not both, is watching television.
4. Either Dale and Cleo are both watching or they are both not watching television.
5. If Ellsworth is watching television, then Abner and Dale are also watching.

The Truth Teller and the Liar:

A space traveler landed on the planet Quartz and as he was strolling through a canyon he met two of the inhabitants. He knew that one was a "truth teller" and the other one was a "liar," so he decided to ask one of them if he was a "truth teller."

"Goom," said the tall native in response to his question.

"He said yes, but him big lier," remarked the short native.

Which native was the "truth teller" and which was the "liar?"

Three men who wanted to be space astronauts were being tested to find out how fast each could reason. These three men, A, B, and C, were blindfolded and a red or black hat was placed on each of their heads. Then their blindfolds were removed and they were told to raise their right hand if they saw a red hat. Immediately all three raised their right hands. Then they were told, "If you know the color of the hat on your head, you are to leave the room." Two minutes later, C left the room. How did C know what color hat he had on top of his head if he could not see his hat and there were no other hats in the room, except for the three hats on their heads?

Answers:

Dale and Cleo are both watching television, and Beryl, Abner, and Ellsworth are not watching television. In looking at statement number 5, if Ellsworth is watching television, then all five will be watching television if statements 1 and 4 are considered. But that is in direct contradiction to statement 3. Therefore Ellsworth is not watching television. Also Dale has to be watching television. Looking at statement 4, you see that Cleo is watching television. Therefore in number 3, Beryl isn't watching television. And in number 1, Abner isn't watching television either.

Answers to the truth problem:

The answer to this is very simple when you realize that the tall native has to answer yes to the question. Since the short native said that the tall native said yes, he has to be the "truth teller" and the tall native has to be the "liar."

Answer to the hat problem:

C could reason this way: If he had a black hat and the other two had red hats, A and B would know that they had red hats because if there were two black hats, all three men would not raise their hands. Therefore C had a red hat because A and B did not leave the room. If A or B had a black hat, C would reason that in order for A and B to both raise their hands, they would have to see a red hat on his head.

IN THE ROUND . . .

(Continued from Page 22)

glazed insulating glass unit known as Twindow, a development of Pittsburgh Plate Glass Company, was used to assure a clear view of the exterior scene during every season as well as to help maintain comfortable temperatures in the home the year 'round. Because the view is important in the Bauer home, the double glass windows were required to keep window condensation to a minimum and to keep the window areas insulated against cold and heat.

At one end of the connecting entrance corridor is a small balcony, reached through sliding glass doors, which serves as a private lookout tower for the Bauers. Immediately adjacent to the front door in the entrance corridor are suspended steps that lead to the large game room and open porch on the lower level of the house. With this plan, the various sections of the house can be reached without inconvenience.

The Bauer home, which contains 3,800 square feet of living space, is designed for working efficiency as well as aesthetic appeal. By utilizing his unique double-circle plan, Architect Bauer resolved a difficult site problem and built a home for his family that has unusual compactness and extreme livability. For the Bauers, their round house's outstanding beauty and livable quality stem largely from the unusual use of glass that makes it possible to have indoor-outdoor beauty to live with during the four seasons.

As Orville Bauer proves, the best blueprint for living doesn't always follow a conventional plan. Homes should and can adapt to their setting to take full advantage of landscape and the natural view that can be found through the windows.

New Muffler for 'T-Bird'

For the first time in the auto industry a new muffler made of a new stainless steel is going on an American production car. More than 50 per cent of the muffler will be stainless steel with stainless being used in critical areas.

The new muffler Ford Motor Company is now putting in the 1961 Thunderbird will last at least three times as long as the standard muffler used on most of today's automobiles.

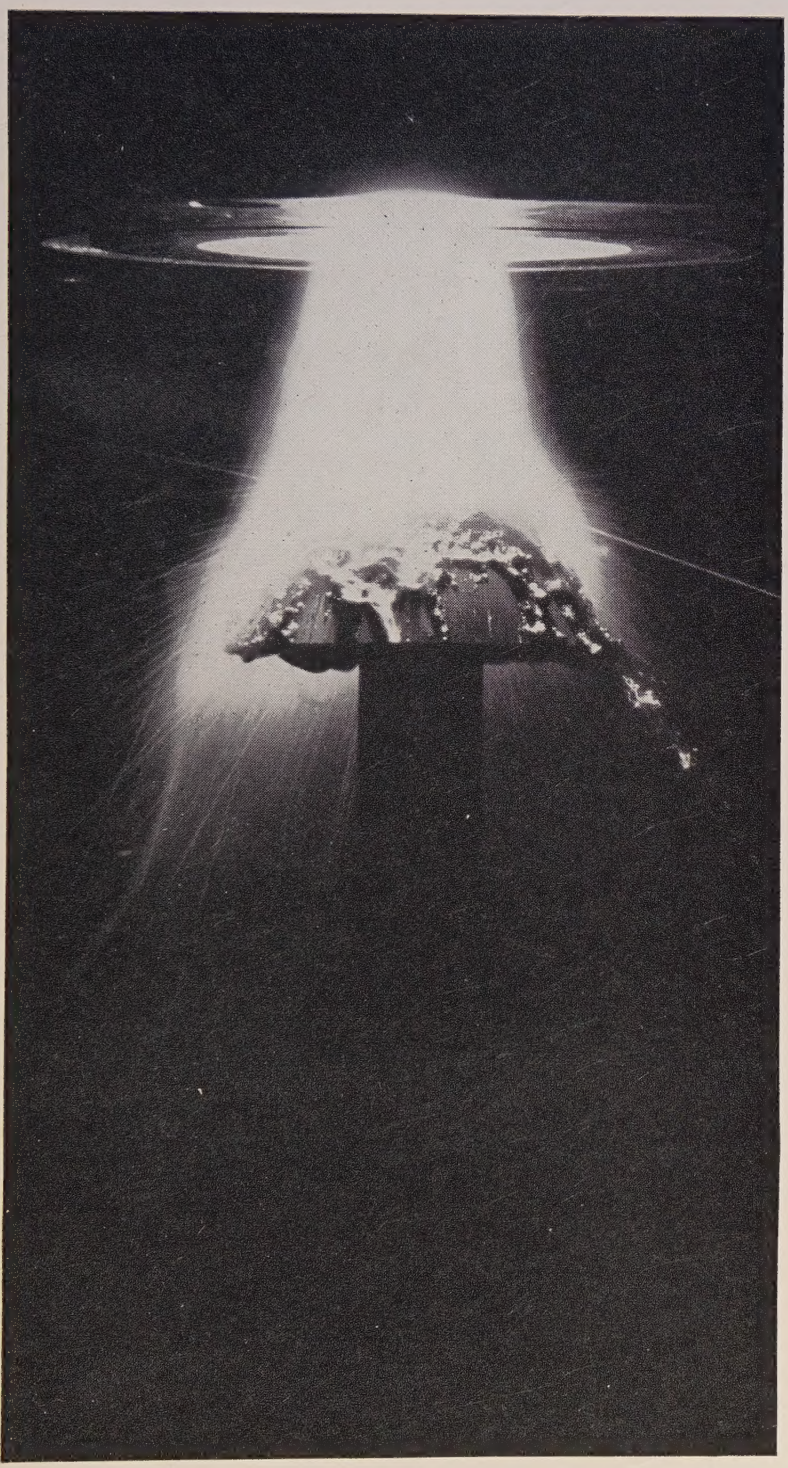
The new steel for the improved muffler was developed by Allegheny Ludlum Steel Corporation over a two-year period.

The truck knocked down the little old lady who was crossing the street.

Truck driver: "Look out!"

Old lady: "Why are you coming back?"

If your sights are set on research and development–



Jet heat blast of more than 15,000 degrees Fahrenheit flares over surface of an experimental nose cone shape in a physics laboratory of Avco Research and Advanced Development Division, Wilmington, Mass.

–you'll find **Photography at Work** with you

Research and development engineers find photography one of their most versatile tools. Camera and film can record the readings of instruments—can capture for study the fleeting transient on the oscilloscope face. The content and structure of metals can be studied by photospectrography or x-ray diffraction. And stresses in parts are visualized by photographing plastic models with transmitted polarized light.

There's hardly a field on which you can set your sights where photography does not play a part in simplifying work and routine. It saves time and costs in research, on the production line, in the engineering and sales departments, in the office.

So in whatever you plan to do, take full advantage of all the ways photography can help.

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One of a series

Interview with General Electric's

Francis J. Boucher

Manager-Manufacturing Personnel Development Service

How Good Is Your Best Job Offer . . .

Q. Mr. Boucher, with all the job interviews a graduating engineer goes through, how can he be reasonably sure he has made the right choice?

A. This is a good question because few seniors have enough work experience in industry, government and educational institutions to allow them to make a fully reasoned choice. However, I think the first step is to be sure that short-term factors like starting salary and location don't outweigh long-range factors like opportunity and professional growth. All of these factors should be evaluated *before making a final commitment.*

Q. But you do feel that starting salary is important?

A. Very much so. If you are married—it may be an even greater consideration. But you should also look beyond starting salary. Find out, for example, if the company you are considering has a good salary administration plan. If there is no way of *formally* appraising your performance and determining your appropriate rewards, you run the risk of becoming dissatisfied or stalemated due to neglect of these important considerations.

Q. What considerations do you feel should be evaluated in reaching a job decision?

A. Let me refer you to a paper written by Dr. L. E. Saline, now Manager of Information Systems in our Defense Systems Department. It is titled "How to Evaluate Job Offers." (Incidentally, you may obtain a copy by writing as directed in the last paragraph.) In it, Dr. Saline proposes six questions—the answers to which should give you much of the information you'll need for an objective job-offer evaluation. He suggests you determine . . .

- to what degree will the work be challenging and satisfying?
- what opportunities are available to further develop abilities?
- what opportunities are there for advancing in the Company (and how dynamic the Company is in the marketplace is an important aspect of this question).
- what salary potentials are possible with respect to the future?
- what about geographical location —now and in the future?
- what effort does the Company make to establish and maintain a professional climate?

There is more to these questions than meets the eye and I think you would enjoy reading Dr. Saline's paper.

Q. What about the openings on defense projects that are listed in the various magazines and newspapers?

A. Presumably, there will always be a need for technical manpower in the defense business. But I want to point out to you that most of these opportunities are for experienced personnel, or personnel with specific additional training received at the graduate level.

Q. How do you feel about training programs? Do they offer any particular advantages over any other offer I might accept?

A. I feel training programs are particularly helpful in easing the transition from an academic to a business environment. Of course they provide formal training designed to add to the individual's basic fund of knowledge. They also provide working experience in a variety of fields and a broad knowledge of the company concerned and its scope of operations. Upon completion, the individual is generally better prepared to decide the direction in which he will pursue his professional career.

General Electric conducts a number of training programs. Those that attract the greatest number of engineers are the Engineering and Science, Manufacturing, and Technical Marketing Programs. Each combines a formal, graduate-level study curriculum, on-the-job experience, and rotating assignments. There is little question in my mind that when an engineer completes the Program of his choice, he is far better prepared to choose his field by interest and by capability. I might also add that because of this, he is more valuable to the Company as an employee.

Q. Then you feel that a training program is the best alternative for a graduating engineer?

A. Not always. Some seniors have already determined the specific field they are best suited for in terms of their own interests and capabilities. In such cases, direct placement into this specific field may be more advantageous. Professional self-development for these employees, as for all General Electric technical employees, is encouraged through a variety of programs including the Company's Tuition Refund Program for work toward advanced degrees, in-plant courses conducted at the graduate level, and others designed to meet individual needs.

Q. For the record, how would you rate a job offer from General Electric?

A. I've tried to get across the need for factual information and a long-range outlook as the keys to any good job evaluation. With respect to the General Electric Company, seniors and placement offices have access to a wide variety of information about the Company, its professional environment and its personnel practices. I think qualified seniors will also discover that General Electric offers professional opportunity second to none—and starting salaries that are competitive with the average offered throughout industry today. From the above, you can see that I would rate a job offer from General Electric very highly.

Want more information about General Electric's training programs? You can get it, together with a copy of Dr. Saline's paper "How to Evaluate Job Offers" by writing to "Personalized Career Planning," General Electric Company, Section 959-15, Schenectady 5, New York.

GENERAL ELECTRIC